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Mr. E. R. CARTWRIGHT has returned to Singapore.

Mr. E. S. HILLMAN is home from Trinidad.

Mr. KAMEN KAYE is leaving for Venezuela.

Dr. W. A. MACFADYEN is in Egypt.

Mr. ALBERT MILLAR has returned to Poland.

Mr. A. W. H. PHELPS is returning to Ceylon by Bibby Line *Cheshire* on November 25th.

Mr. C. V. RUTHERFORD has returned to Persia.

Mr. F. C. WATERS has returned to Abadan.

Mr. A. T. WHITE has gone to Iraq.

Mr. S. R. WILSON has left for Illinois, U.S.A.

The Secretary would be glad to learn of the whereabouts of the following members: E. E. G. AGIUS, E. J. S. HEWITT, J. JAWAD JAFAR, A. MACLEAN, D. J. PULL and R. W. STILES.

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The following additions have been made to the Library since June 1, 1933 :—

AMERICAN SOCIETY FOR TESTING MATERIALS. A.S.T.M. Standards on Petroleum Products and Lubricants, 1933.
—— Symposium on Motor Lubricants, 1933.
ASHWORTH, ARTHUR A. The Analysis of Oil for the Production of Lubricants.
AUSTRALIAN CHEMICAL INSITUTE. Tentative Standard Methods for the Sampling and Analysis of: (1) Cement, (2) Copper and (3) Oils, Fats and Waxes.
BIERHALTER, W., AND OTHERS. Wie prüft man Strassenbaustoffe.
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—— B.S.S. 494–1933. Cold Drawn Weldless Steel Boiler and Superheater Tubes.
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DIESEL ENGINE USERS ASSOCIATION. Some Notes and Observations on Petrol and Diesel Engines. H. R. Ricardo.
—— The Vibrations of Oil Engines. P. Jackson.
EGLOFF, GUSTAV. Earth Oil.
ENGINEER, THE. 1913, 1925–1929.
ENGINEERING. 1913–1931.
FUEL RESEARCH. The Viscosity of Pitch. A. B. Manning.
—— An Investigation into the Accuracy of Routine Analytical Determinations of Coal and Coke. H. V. A. Briscoe, J. H. Jones and C. B. Marson.
GEOLOGICAL SURVEY OF GREAT BRITAIN. The Country around Holmfirth and Glossop. C. E. N. Bromehead and others.
INDIA, GEOLOGICAL SURVEY OF. RECORDS, Vol. LXVI., Pt. 4; Vol. LXVII., Pt. 1, 1933.
INSTITUTE OF MARINE ENGINEERS. Forty-Fourth Annual Report and Financial Statement and Minutes of Annual General Meeting.
INSTITUTION OF AUTOMOBILE ENGINEERS. Proceedings of the Session, 1932–33.
INSTITUTION OF MECHANICAL ENGINEERS. Proceedings, 1932.
IRON AND STEEL INSTITUTE. Journal, Vol. CXXVII., No. 1, 1933.
JAVA, GEOLOGISCHE KAART VAN. Toelichting bij blad 14 (Bajah), 30 (Poerwakarta), 67 (Bandjarnegara).
KRANZLEIN, GEORG. Aluminiumchlorid in der Organischen Chemie.
LOUISIANA DEPT. OF CONSERVATION. Geol. Bull. 3.
—— Geology of Lafayette and St. Martin Parishes. H. V. Howe and C. K. Moresi.

MUSCAT, M., AND R. D. WYCKOFF. A Theoretical Analysis of Water-Flooding Networks. A.I.M.M.E. Tech. Publ. No. 507.

NEW ZEALAND DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. The Briquetting of New Zealand Coals. W. A. Joiner, W. G. Hughson and A. K. R. McDowell.

ROHLFFS, W. V. Der Erdölbergbau in Vergaugeuheit und Zukunft.

SOCIETY OF AUTOMOTIVE ENGINEERS. Handbook, 1933.

SUMATRA, GEOLOGISCHE KAART VAN. Toelichting bij blad 3 (Bengkœnat), 6 (Kroei), 15 (Praboemoelih).

TRINIDAD AND TOBAGO, MINES DEPT. Administration Report of the Inspector of Mines for the Year 1932.

UGANDA PROTECTORATE. Annual Report of the Geological Survey Dept. for the Year Ended 31st December, 1932.

UNITED STATES BUREAU OF MINES. Crude Petroleum and Petroleum Products in 1931. G. R. Hopkins and A. B. Coons.

—— Natural Gasoline in 1931. G. R. Hopkins and E. M. Seeley.

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—— Information Circular 6721. Accident Experience of Four Louisiana Petroleum Refineries. F. E. Cash.

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—— Information Circular 6745. About Helium. A. Stewart.

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—— Report of Investigations 3211. A Study of Sub-surface Pressures and Temperatures in Flowing Wells in the East Texas Field and the Application of these Data to Reservoir and Vertical-Flow Problems. C. E. Reistle and E. P. Hayes.

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—— Report of Investigations 3217. Estimate of the Gas Reserves of the Oklahoma City Oil Field, Oklahoma County, Okla. H. B. Hill and E. L. Rawlins.

—— Statistical and Economic Surveys. Asphalt Demand and Production Decline One-sixth in 1932.

U.S. GEOLOGICAL SURVEY. Bull. 830–B. Geology of the Robertson, Humdinger and Robert E. Gold Mines, Southwestern Oregon. P. J. Shenon. Notes on the Chieftain and Continental Mines, Douglas County, Oregon. F. G. Wells.

—— Bull. 839. Geology of the Boston Area Massachusetts. L. LaForge.

—— Bull. 840. Geology and Mineral Resources of the Middletown Quadrangle, Pennsylvania. G. W. Stose and A. I. Jonas.

—— Bull. 841. Geology and Oil Possibilities of the Moab District, Grand and San Juan Counties, Utah. A. A. Baker.

—— Bull. 844–A. Mineral Industry of Alaska in 1931 and Aministrative Report. P. S. Smith.

—— Circular 1. Iron Ore in the Red Mountain Formation in Greasy Cove, Alatawa. E. F. Burchard.

—— Circular 2. Copper Deposits in the Squaw Creek and Silver Peak Districts and at the Almada Mine, Southwestern Oregon, with Notes on the Pennell and Farmer and Banfield Prospects. P. J. Shenon.

—— Professional Paper 175–D. Origin of the Anhydrite Cap Rock of American Salt Domes. M. I. Goldman.

YACIMIENTOS PETROLIFEROS FISCALES. Desarrollo de la Industria Petrolifera Fiscal, 1907–1932.

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As Transfer to Members.		
CLARK, Percy Robert, Engineer, Bariere Campina, Ploesti, Rumania	J. E. Treacy	F. W. Penny
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As Associate Members.		
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DELMAR-MORGAN, Edward Locker, Engineer, c/o Rising Sun Petroleum Co., 58, Yamashita-cho, Yokohama, Japan	H. P. B. Jones	P. E. Joyce
DOWNS, William Webster, Engineer, Shell Co. of Ceylon, Ltd., Colombo, Ceylon	P. Kerr	E. R. Cartwright
IEVANOFF, Victor, Chemist, Societe Anme. A. Andre Fils, 8, Rue de la Tour des Dames, Paris (9e), France	E. Thomas	F. H. Garner
MOIR, John, Engineer, c/o Rising Sun Petroleum Co., 58, Yamashita-cho, Yokohama, Japan	P. E. Joyce	P. Kerr
PEARSON, Roy Taylor, Engineer, c/o Rising Sun Petroleum Co., 58, Yamashita-cho, Yokohama, Japan	H. P. B. Jones	P. E. Joyce
PRESTON, John Scott, Engineer, 1, Rosecroft Avenue, Hampstead, N.W. 3	G. W. Lepper	C. A. Sansom
ROBINSON, John Basil, Engineer, Trinidad Central Oilfields, Ltd., Tabaquite, Trinidad, B.W.I. ..	A. Duckham	F. Middleton
SPLITTER, Barnard, Engineer, "The Limes," 16, Woodberry Down, N. 4	E. R. Redgrove	W. H. Howe

As Associate Members.	*Proposed by*	*Seconded by*
WINTERBOTTOM, Archibald, Engineer, c/o The Rising Sun Petroleum Co., Ltd., Tamsui, Formosa	P. E. Joyce	Peter Kerr
As Transfer to Associate Members.		
DAVIES, Tewdwr Griffith Bowen, Geologist, c/o Messrs. Steel Bros., Indo-Burmah Petroleum Co., Ltd., P.O. Box 132, Rangoon, Burma..	A. E. Day	C. Ross
HARLAND, Herbert, Operator-Cracking Plant, c/o Anglo-Persian Oil Co., Ltd., Abadan, Persian Gulf..	S. Nicol	C. J. Wright
HOWARD, Giles Philip Eliot, Engineer, Windmill House, Coleshill, Bucks	F. E. Howard	G. W. E. Gibson
KAMEN KAYE, Maurice, Geologist, c/o Caracas Petroleum Corporation, Apartado 587, Caracas, Venezuela, South America ..	V. C. Illing	L. Owen
SHAW, Otto Leslie, Chemist, Betual, Park View Row, New Eltham, S.E. 9	J. S. Jackson	J. Kewley
STEVENS, Leonard Charles, Engineer, c/o United British Oilfields of Trinidad, 15, Abercromby Street, Port of Spain, Trinidad, B.W.I.	A. W. Nash	A. R. Bowen
As Students.		
BOYD, William Reid, Student, c/o Ewart, 12, Gledstanes Road, Barons Court, W. 14	V. C. Illing	
CHILDS, John Leslie, Laboratory Assistant, Gifford's Cross Farm, Corringham, Stanford-le-Hope, Essex	J. S. S. Brame	L. Clement
HAWORTH, Alfred John, Student, 8, Park Hill Court, Park Hill, Ealing, W. 5	V. C. Illing	
MESTRE, Richard Etienne de, Student, 61, Lambton Road, S.W. 20	V. C. Illing	
PACHACHI, Nadim, Student, 73, Oakley Street, Chelsea, S.W. 3 ..	V. C. Illing	
SANGSTER, Eric Bruce, Student, 124, Bournbrook Road, Selly Park, Birmingham	A. W. Nash	A. R. Bowen

No. 121. Vol. 19.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE ONE HUNDRED AND FIFTY-FIRST GENERAL MEETING of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, October 10th, 1933, **Mr. T. Dewhurst** (President) occupying the Chair.

The Secretary read the names of candidates nominated for election, and the following list of members elected :—

As Members.—N. Danaila, William Kirkwood Dykes, Jan Versluys.
As Transfer to Member.—David Spiers Paul.
As Associate Members.—Frederick Alexander Chuter, Griffith Vivian Davies, Stanley Penberthy Harris.
As Transfer to Associate Member.—Reginald Frank Alfred Baldwin.
As Student.—Gilbert Lloyd Holloway.
As Associates.—William Lawrence Gray, William Henry Green.

The President explained that on March 11th, 1930, Major Goddard read a paper to them on "The Diesel Engine as Applied to Road Transport," and that Dr. Dunstan, the then President, introduced Major Goddard as a member of the Institution of long standing and as an eminent specialist in his particular line, and referred to the great interest evoked by the exceedingly important subject matter of his paper. That evening therefore he could only stress every word uttered by Dr. Dunstan on that former occasion, and add that all members would be eager to hear the present paper which recorded progress during the past 3½ years.

The following paper was then read :—

The Modern High-Speed Diesel Engine, and its Place in Road Transport.

A brief résumé of 5½ years' experience in Great Britain.

By W. H. GODDARD, A.M.I.Mech.E. (Member).

SINCE the reading of a paper to this Institution in March, 1930, on the subject of high-speed Diesel Engines for Road Transport purposes,[1] some 3½ years have passed by. These 3½ years have been very full of all sorts of interesting and exciting happenings —in politics, in industry and in every phase of our life, most of which have been accorded ample limelight. One of the most important, however—*i.e.*, the coming of the high-speed Diesel engine in road transport—has not perhaps had the limelight it deserves. It is, therefore, with a hope that this humble effort to put before you a brief résumé of what has been achieved in

[1] *J. Inst. Petr. Techn.*, 1930, **16**, 423–449.

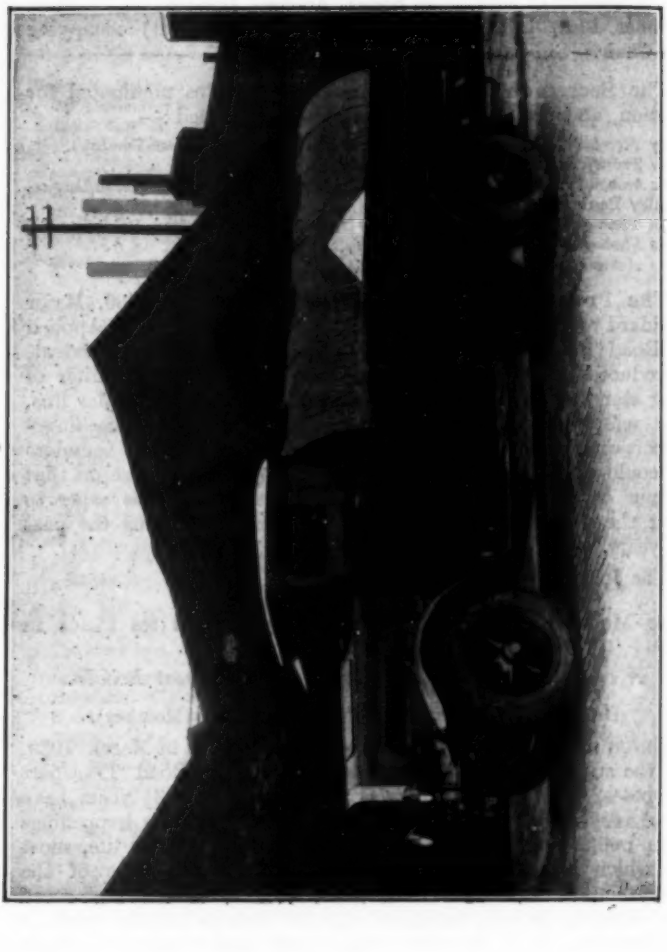

FIG. 1.

THE FIRST DIESEL-ENGINED LORRY—MERCEDES BENZ SIX-CYLINDER ENGINE.

this direction may be of interest and possibly of help, more especially to those whose interests are bound up with the petroleum industry and the motor transport industry—the combination of which, one may say, is to-day the main basis of our civilised existence.

The actual start dates from April, 1928, when two Continental made (pre-chamber type engines) heavy lorries were imported—both of these vehicles are still running well and have covered enormous mileages. Thus our experience here covers about 5½ years. It is difficult to arrive at the exact number of Diesels now on the road here—more especially as new engines are being turned out at the rate of about 80 to 100 or more per month, but it is safe to estimate the total at between 2000 and 2400. When considering the question of the rate of progress made we must bear in mind that for more than two years after the start, practically no progress was made, and it was difficult in those days to persuade motor users that this was anything but "just a new freak machine" which would soon pass out. At that time only complete chassis were available, and they were imported: very expensive—and only suitable for heavy loads. Later on, when the Diesel was becoming better known, the severe trade depression and its accompanying scarcity of money was another factor against the Diesel; then came the long and trying scare known as the "Salter Committee Report," which almost paralysed the motor trade for a long period, the Diesel, of course, suffering in this like the gasoline engine—all these items contributed to the retardation of the progress of the Diesel engine. However, the great advantages of the Diesel kept it always well to the front, and many motor users who have been patiently "watching and waiting" are now purchasing these engines. The great majority of the engines being sold are not for new chassis, but for conversion purposes, the economy being so great that provided the vehicle runs a fair mileage—say, 500 miles per week or more—it is a very paying proposition to remove the petrol engine and replace it with a Diesel. So much so, indeed, that it is quite usual for the buyer to be able to recover the total cost of engine and work of fitting in from 12 to 18 months running, out of the fuel economy alone. Many firms have started with one conversion, and after a reasonable run of, say, three to four months, have come back for another, and have kept on converting as fast as funds would permit.

The first Diesel-engined bus was put into service in Sheffield on March 9th, 1930—this was a Continental pre-chamber engine—but it is only comparatively recently that Corporations and Omnibus Companies generally have come to realise the many and the great advantages of the Diesel engine and its complete suitability for passenger as well as goods transport. It may be news to many

FIG. 1.

THE FIRST DIESEL-ENGINED LORRY—MERCEDES BENZ SIX-CYLINDER ENGINE.

that the L.G.O. Co. have now 112 Diesel buses running regularly in London—possibly one of the most difficult towns in the world as far as police and traffic restrictions are concerned—and I venture to say that not one passenger in 500 realises that they are anything different to the usual petrol-engined buses.

The Chief Engineer of the L.G.O.C., the late Mr. G. J. Shave, in a report on his experience with Diesel engines, drew the following conclusions after a total of 575,000 bus miles run :—

"That there is a definite future for the high-speed oil engine for omnibus operation for the following reasons :

(1) Higher specific economy in fuel consumption ;

(2) The safety factor, *i.e.*, immunity from fire risk both on the road and in the garages, and relief from restrictions ;

(3) The enhanced accelerating capabilities and well-sustained torque of this engine facilitate driving in congested areas ;

(4) No time wasted in warming up and starting from cold, thus reducing fumes in garages where many buses are collected ;

(5) Reduced amount of carbon monoxide in exhaust gases making them innocuous."

This, one can say, is most distinct progress. In the provinces and the North more especially the Diesel bus is now coming into its own. The Leeds Corporation recently ordered 18 new buses —6 of them direct injection Diesel's and 12 petrol ; this Corporation has been running 1 Diesel bus (fitted with a Gardner engine) for three years—a pretty thorough test, covering about 110,000 miles run. It is significant that almost every Corporation now, when inviting tenders for new buses, state "either with oil or petrol engines."

Long distance coach companies have been—curiously enough—very slow to take up the Diesel engine—I say "curiously" because the Diesel is the ideal engine for this work and the economy in fuel is enormous. Take for example the Newcastle to London trip—270 miles approx. Running six single trips per week the saving in fuel alone amounts to approx. £400 per year. Recently, however, several long distance buses with Diesel engines have been put into service, and it is safe to prophesy that there will soon be a big increase in this direction. On the goods side there are now many firms who have gone completely over to Diesels—fleets of 5 to 10 Diesels being quite common, others have up to 25 and are still increasing, and one railway company bought 139 Diesels in one order and are still buying more. It must be remembered, however, that out of some 360,000 goods lorries on the roads in this country, the great majority are of the 1 ton and 1½ ton class for which up to very recently there has not been

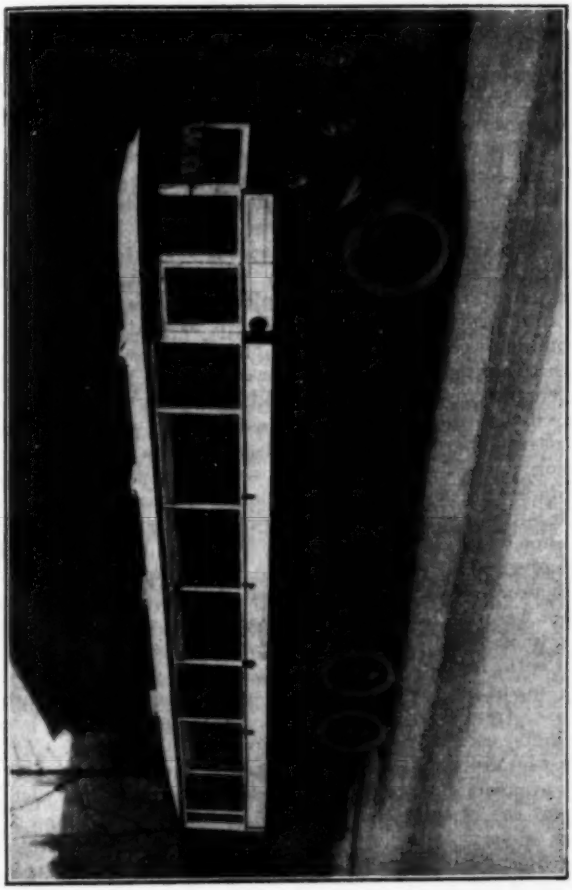

FIG. 2.

THE FIRST DIESEL BUS, SHEFFIELD, 1930—MERCEDES BENZ ENGINE.

available a Diesel engine small enough—even at this moment there is not available a 4-cylinder engine really small enough for this type of lorry. Although there are a few 2-cylinder engines (24 b.h.p.) fitted to 30-cwt. lorries which are quite good but not as satisfactory as 4-cylinder units. Recently there has been also a 3-cylinder direct injection engine—51 b.h.p.—put on the market for 2/3½ ton lorries, but what we really require is a small 4-cylinder engine of about 2 litres capacity for very light lorries and cars. These are coming in due course, but the price must be brought down to within a reasonable proportion of the price of the lorry. The new scale of duties for goods vehicles which comes into force on January 1st next will tend to bring about a great increase in the number of small lorries—2 to 3 tons—and this will force matters towards the production of small Diesels.

In this period of 5½ years, perhaps the greatest and most important progress made was when in March, 1930, an all-British Diesel engine of the simple direct injection type was produced and put into road transport service. Up to that time, all the engines running were either of the pre-chamber type or the air-cell type, with the exception of one or two opposed piston 2-stroke German engines. The simplicity and reliability of the direct injection engine—the elimination of complicated cylinder heads, heavy electrical starting gear, serious heat losses and extra high compression ratios—were at once apparent, and this engine was an immediate success. It was first run at a maximum speed of 1300 r.p.m.—the same speed as the original two Continental engines in 1928—but when the second edition came out some 16 months later, many great improvements were incorporated, including a great reduction in weight and an increase of speed up to 1700 r.p.m. Here again was very marked progress—hand starting from dead cold in any weather and smoother running were also items of progress, both important. Economy in fuel consumption also forms an important item in progress—whilst the earlier imported engines used from 0·45 to 0·55 lb. oil per b.h.p. hour, the latest British engine uses 0·370 to 0·402 lb. oil per b.h.p. hour. Motor engineers who are accustomed to working in pints per b.h.p. hour will fully appreciate what this means when one mentions that at 1200 r.p.m. the consumption is 0·345 pint per b.h.p. hour; it represents a very extraordinary thermal efficiency and a great achievement. Further progress is represented by the recent importation of a complete 45/55 cwt. Continental-made lorry with a 4-cylinder 3·77 litre pre-chamber type engine of a famous make which promises to be of considerable interest.

Taking into consideration, therefore, all that has been done in the short period of approximately 3½ years, and in spite of all the

adverse conditions and the difficult period through which we are passing, very great and important progress has been made in the application of the Diesel engine to road transport. Some items of this progress are as follows :—

(1) Weights have been reduced from about 26 lb. b.h.p. to under 15 lb. per b.h.p.—approximately 42 per cent.—a considerable reduction.

(2) Speeds have been raised from 1300 to 1700 r.p.m.—approximately 30 per cent. without affecting exhaust consumption or noise.

(3) Complete elimination of exhaust smoke.

(4) Noise and rough running reduced almost to normal petrol engine conditions.

(5) Fuel consumption per b.h.p. hour improved from 0·450 lb. to 0·370 lb. with increased torque and higher b.m.e.p.

(6) Gross ton mileage per gallon of fuel increased very considerably.

(7) The application of this engine to passenger vehicles of every type has been proved to be completely suitable and successful under all conditions.

(8) The great advantages of the direct injection engine over the pre-chamber and air-cell type of engine have been amply proved.

(9) One manufacturer has succeeded in completely eliminating fuel dilution of the lubricating oil in a direct injection engine—the improvement being brought about by alteration of the design of the sprayer nozzle only—a remarkable achievement and of *great importance*.

At this juncture it becomes necessary to explain the very peculiar position which prevails in the actual manufacturing industry of these high-speed Diesel engines in this country to-day. For very sound and logical reasons one particular make of engine—a direct injection British engine—dominates the market. The successful manufacture and production of a really efficient high-speed Diesel engine differs very greatly from that of the same thing in petrol engines—*i.e.*, it requires a very great amount of experience in the burning of heavy oil distillates on the Diesel principle, which is, of course, injecting the fuel in a fine spray at or about top dead centre, at maximum compression pressure and temperature, and the firing of the fuel-air mixture by heat of compression only. It is a far more delicate operation to achieve successfully and efficiently than carburation and the firing by electric spark of the compressed mixture as in the petrol engine. It is a completely new phase in Diesel type engine manufacture—an entirely new application of the Diesel engine, requiring light and compact engines running at speeds never before attempted with this type of engine, and the

engines are required to withstand the gruelling which road transport engines have to undergo and which in the early days the Diesel engine was not called upon to do. It requires a vast knowledge of *how to combine efficiently* many contributory items, such as:

(1) Pressure of injection;
(2) Compression ratio and temperature resultant;
(3) Air to fuel ratio;
(4) Turbulence;
(5) Atomisation of fuel and spread of fuel spray;
(6) Direction of fuel spray;
(7) Nozzle design and fuel apertures;
(8) Volumetric efficiency;
(9) Piston design, including rings;
(10) Speed.

It is not one, two or three of these points which has to be mastered, but the combination of all of them, which is required, and only those with a long experience in the burning of distillates on this principle can successfully combine all these items.

Thus we can say that we can now have a Diesel engine for any type of vehicle—passenger or goods—except for the very smallest lorries and for small or medium sized cars. There is however a famous Bentley car fitted with a 4-cylinder Gardner engine which came out with flying colours in the last Monte Carlo rally and which puts up a most remarkable performance—a top speed of about 86 m.p.h., with very powerful acceleration, and a consumption of 32/34 m.p.g. Its R.A.C. rating is 29 and its capacity 5·6 litres.

The Monte Carlo Rally.

A brief reference to the report made by Lord de Clifford—who ran the Bentley-Gardner car—may be of interest.

What the Car Did.—Covered approximately 7000 miles on 250 gallons of fuel oil.

This would only have cost £6 5s. at prices ruling in England.

Running this distance on petrol would have cost about £45.

The speed at 2000 r.p.m. was 76 m.p.h.

The engine started easily on the starter.

The Bentley saloon averaged 28 m.p.g. with "four up."

The overall average speed between controls was 33·9 m.p.h.

From Riga to Konigsberg, about 260 miles, the car averaged 44·5 m.p.g., including all stops and two frontier crossings. The net average works out at nearly 52 m.p.h. The roads were covered in snow in places.

Two things stick in my mind about the 1933 Monte Carlo Rally —the complete lack of trouble during the run and the intense cold. From my own point of view, I can truthfully say that never have I done a more peaceful competition in any vehicle.

It may be of interest to give a few details of the machine. The engine was a 1932 4-cylinder Gardner Diesel, 4¼ in. bore, 6 in. stroke, with a capacity of 5570 c.c., rated at 29 h.p. and fitted into a 1925 long-chassis 3-litre Bentley. The body was the same age—a fabric Freestone and Webb saloon.

Quite a formidable combination, promising every sort of trouble, if looked into carefully! What with the transmission designed for a 15·9 h.p. engine revving at 3700 r.p.m. and being given a 29 h.p. motor revving at 2300 r.p.m., with a weight distribution never intended for the chassis, and, above all, with a crew who, with one exception, knew nothing about the car or how it would behave in any given circumstance.

I may say at once that for real surprises one should drive a Diesel-engined car.

The enormous power which is produced at the first touch of the accelerator, the tremendous acceleration and high cruising speeds are things which I have never experienced in any petrol-driven car of equivalent power or for such low fuel consumption.

Absolutely instant starting in temperatures varying from –25° F. to 60° F., and no spitting or missing when given full throttle immediately. Just the whole strength of a willing engine thrown right into the collar and getting down to the job at once.

Steering Damper Freezes Up.—Our run to the start was uneventful so far as the car was concerned, the only item of interest being that one night, just after entering East Prussia, the Houdaille hydraulic steering damper froze up solid, so that the car could not be turned to right or left.

After a thorough overhaul at Tallinn, we were agreeably surprised to find the chassis showing no signs of the terrific strains and stresses it had been through, the road from Riga to Tallinn being about as bad as any road could be and still go under the name of a road.

The engine was showing no signs of wear and tear and was still functioning in an immaculate manner.

The evening before the start, ominous rumours about snow in Lithuania were drifting about and a mass of fresh chains was furiously fitted by various competitors.

The start was given for us at 4.41 a.m. on Saturday morning, and from then until we arrived at Monte Carlo—with the exception of an oil relief valve sticking twice—our progress was merely a steady journey from one control to another.

All roads came alike to the car. Ruts, snow, snowdrifts, they were all brushed aside by the enormous strength displayed by both engine and chassis.

The log makes uninteresting reading—merely a string of names with ever-increasing time-margins against them; the times of changing drivers and the fact that we perhaps had to change a lamp bulb.

No tales of disaster or woe—just the log of "nothing to worry about."

That is what sticks in my mind about this engine.

There was no worry, no anticipating the collapse of a weak part, and, outstanding, no fumes or smell. I can never recollect ever having done a long run and remaining so fresh. There is none of that slight exhaust smell that is so prevalent on nearly all petrol cars, and, consequently, there is none of that rather heavy-headed feeling which people tend to get after a long drive behind a petrol engine.

Our fuel consumption worked out over all at 28 m.p.g. and our oil at about 1250 m.p.g.

The amazing acceleration of this engine surprised even the crew of the car, who by that time had thought that nothing left in this world could ever stimulate any surprise at all.

My conclusions are, then, these:—

That very shortly a Diesel car will be a practical proposition. That the car, when it does appear, will be such an advance on modern performance of a petrol car that, with the exception, perhaps, of the high-powered luxury vehicle, all petrol cars will be automatically out of date.

Actual Economy Figures.

At the present moment, with the recently imposed duty of 1d. per gallon, the "gas oil" type of fuel being generally used to-day costs 5¼d. per gallon when delivered in 500-gallon road tank lots. The variation in the price of petrol—according to the status of the customer is very great and makes calculations somewhat difficult, but we can take an average to-day of about 1s. 1d. gallon for commercial users. So that we have an advantage of 2·47-1 in price, in favour of our gas oil.

A double-decker bus with a direct injection Diesel engine will run 11 m.p.g. as against 5·8 to 6 m.p.g. on petrol.

A 6 ton lorry will run 15/17 m.p.g. as against 6 on petrol.

A single-decker bus will run 16/18 m.p.g. as against 8 on petrol.

A 15 ton lorry will run 10/11 m.p.g. as against 4½ to 5 on petrol.

It is thus clear that the total fuel economy is in the region of 75 to 80 per cent. while prices remain as they are to-day.

The cost of conversion of vehicles—taking the best engines—is approximately as follows (cost includes engine and the work of fitting, etc.) :—

A single-decker bus, £420.
A double-decker bus, £590.
A 6 ton lorry bus, £390.
A 15 ton lorry bus, £575.

A very recent test on a d.d. bus in a northern city Corporation over 20,000 miles run, showed that the Diesel engine was economising at the rate of £600 per year, thus recovering the whole cost of conversion and engine in under 12 months on fuel alone. Added to this the lubricating oil costs were less than one-half of those with a petrol engine, and as far as could be ascertained the maintenance costs will be well down, and there is a further economy in quick starting, saving time and fuel—especially in the winter months. The engine concerned is a direct injection unit—6-cylinder—102 b.h.p. at 1700 r.p.m. Taking a five years' life for such a bus, it is hard to imagine a better investment for any Corporation bus undertaking or company than the conversion of those vehicles which are still in sufficiently good condition to run five years—or even less.

Exhaust Fumes and Smoke.

It is perhaps unfortunate that the Diesel high-speed engine is at a disadvantage as compared with the petrol engine in the matter of exhaust fumes and its liability to emit black smoke. A badly designed petrol engine in bad order will not emit dense volumes of black smoke continually. A badly designed Diesel engine will, and if it is also in bad order the result is worse. Unfortunately we have on the roads many Diesel engines which have been designed—perhaps in undue haste to gain a market or to keep a petrol engine market—by firms who have not had the necessary experience in the burning of oil distillates to produce a properly designed engine; also we most certainly have a great quantity of Diesel engines on the roads which are not properly looked after and kept in tune. The result is that it is a common sight now to see a Diesel-engined vehicle—even in the towns—emitting volumes of black smoke. It is even so bad that in an important northern city where the Corporation run a large fleet of Diesel buses people are moving out of their houses and property is falling in value owing solely to this smoke nuisance. This is a most serious matter, far more serious than is generally thought, and I earnestly hope that my humble effort at a warning may be taken seriously. The Ministry regulations require: "A perfectly

clear exhaust at all times." We all know that neither with petrol, or Diesel engines is it possible to attain this perfect state of affairs, but it is certainly possible to keep engine exhausts reasonably clear so that the authorities cannot reasonably complain or take action. But if the present serious state of affairs is allowed to continue, and with the rapid increase of Diesel vehicles, it is quite certain that some drastic action will be taken—and as it is not reasonable to hope that the authorities will discriminate as to makes or types of engines, it means that there is a positive danger of Diesel engines being prohibited on the roads altogether. A properly designed Diesel engine, kept in proper tune, does not emit smoke; at the most, a faint blue haze at times, varying with atmospheric and other conditions, but no worse than a petrol engine and in no way objectionable. Such an engine, running on dirty fuel oil, or with the sprayers in need of cleaning, or the timing chain stretched, or needing decarbonisation, will smoke, and possibly badly. The gas oils and fuel oils generally being now supplied require "centrifuging" before use; the engine should have adequate strainers and an extra strainer between the main fuel tank and the injection pump, also a strainer in the sprayer. Sprayers require to be taken out and cleaned at regular intervals. The timing should be checked also at regular intervals, and although the formation of carbon is much less than with petrol engines, it also requires to be removed at certain intervals, just as with petrol engines. It is up to the user to keep his engines in tune. With regard to those engines which are badly designed and therefore incurable in respect to exhaust smoke, one can only hope that the makers, as a result of inevitable and continual complaints and for their own eventual benefit, will take steps to find the faults and bring their engines up to date with a reasonably clear exhaust when in proper tune. This smoke trouble applies equally to direct injection, pre-chamber and air-cell engines. It is up to the makers who are at fault to get busy on this serious matter at once. One firm at least has evidently realised the gravity of this matter, and has changed over from direct injection to a type of pre-chamber head, but the design is still faulty and the smoke trouble is not entirely eliminated.

It is fair, also, to mention that the fuel oil itself is sometimes to blame. In a recent case of smoke trouble, it was found that the sprayers coked up in three or four days' run and caused considerable smoke. Another fuel of the same type and very similar specification was tried out, and the engine ran "smokeless" for five weeks. Both fuels were supplied by well-known importing companies. There is undoubtedly a great need for co-ordinated research in the matter of fuel oils for these engines and more

especially for the formulation of a standard method of testing the fuels. A perusal of the papers read at the recent "World Petroleum Congress" gives one hope that both of these needs may be met in the near future.

Direct Injection *v.* Pre-Chamber Engines.

The modern high-speed Diesel engine is now being made in two definite and distinct categories—*i.e.*, "Direct injection" or open chamber, also known as "one-cell engines," and "pre-chamber" or two-cell engines; of the latter type there are so many variations that it is somewhat difficult to keep pace with them, they remind one of "permutations and combinations."

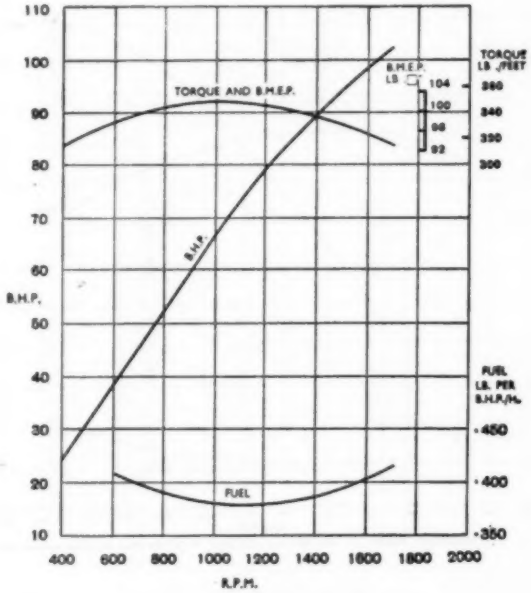

Fig. 3.

IDEM OF A DIRECT INJECTION ENGINE.

There are 20 distinct makes of engine on the British market designed for road transport use, of which 8 are direct injection and 12 are of various types of "chamber" head. Of the 20 different makes only 6 have become well known. Of these 6, 3

are "direct injection" and 3 are of the "chamber" type, and 1, a direct injection unit, completely dominates the market.

Points of comparison between the two types of engine.

Pre-Chamber Engines.

(1) Complicated and therefore expensive cylinder head construction, occupying valuable space, liable to heat distortion and heavy.

(2) Considerable loss of heat due to the burning gases having to pass through restricted passages between the chamber and the cylinder.

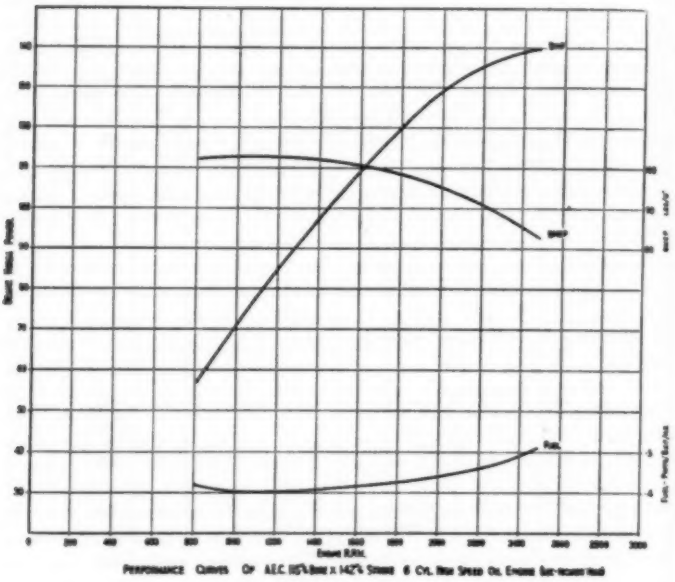

Fig. 3A.

POWER AND CONSUMPTION CURVE OF A PRE-CHAMBER ENGINE.

(3) The need for heater plugs to warm up the chamber for starting purposes, which calls for heavy batteries both for heating and starting, with disadvantageous added weight.

(4) The need for high compression ratios—15½ to 16½—1 being usual to obtain the necessary heat for starting. This entails heavier parts and therefore added weight.

(5) The extra expense of electrical gear—both first cost and maintenance.

(6) Power output and efficiency so reduced as to bring about a loss estimated to be 15 to 20 per cent. as compared with direct injection.

(7) Liability to cracked pistons owing to concentrated heat from the chamber outlet impinging on the piston crown.

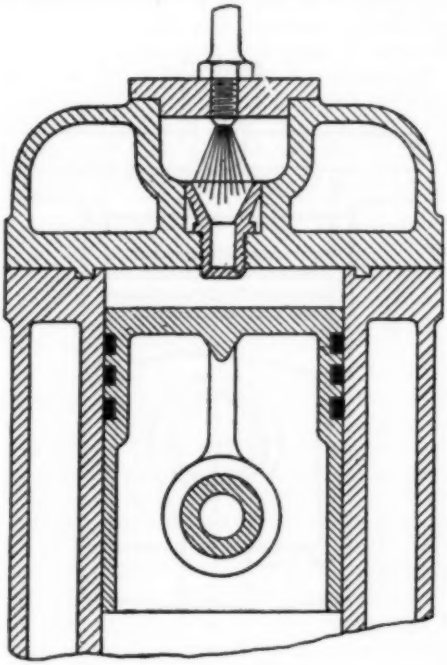

FIG. 4.
TYPICAL PRE-CHAMBER HEAD.

DIRECT INJECTION ENGINES.

With particular reference to the Gardner engine :—

(1) The cylinder head is similar in design, and therefore equally simple in construction, to that of the modern overhead valve petrol engine, and occupies no more space.

(2) There is no loss of heat in restricted passages—the fuel being sprayed directly into the cylinder where it is in immediate contact with the heated air charge.

(3) The engine starts easily by hand alone from dead cold and no electrical or mechanical gear is required.

(4) No heater plugs or primers of any sort are required.

(5) A lower compression ratio is employed, thus saving weight with reduced stresses—*i.e.*, 13—1 ratio.

(6) Greater reliability owing to the absence of heater plugs and auxiliary gear.

(7) Approximately 15 per cent. to 20 per cent. greater economy in fuel.

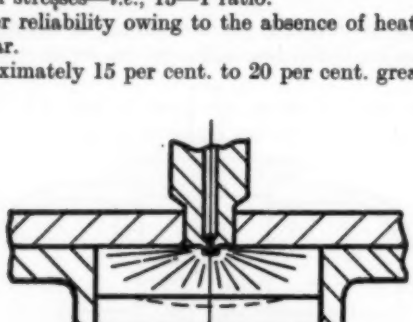

FIG. 5.

TYPICAL DIRECT INJECTION HEAD.

Has the chamber engine any special advantages? It has been claimed that:

(*a*) It enables lower injection pressures to be employed.

(*b*) That the precise direction of the spray is of no importance.

(*c*) That the actual fuel spray orifice can be comparatively large thus eliminating risk of obstruction.

(*d*) That it will enable a greater range of hydrocarbon fuels to be burned.

(*e*) That it produces a very violent turbulence.

With regard to (*a*). The usual injection pressure of the P.Ch.E. is about 950/1000 lb. per sq. in. That of the D.I.E. is generally somewhat over 2000 lb. per sq. in. Results taken over many hundreds of thousands of miles run, prove conclusively that no leakage or other troubles have ever been found to result from the use of 2000/2300 lb. pressure in the injection pumps and sprayers.

With regard to (*b*). The precise direction of the spray is of the greatest importance in the D.I.E., but each manufacturer knows what his own engine requires and provides accordingly, and therefore this cannot be put up as an advantage or otherwise.

With regard to (*c*). There are many thousands of sprayers actually working on the road to-day in which the fuel orifices are only ten thousandths of 1 in. dia., and no trouble whatever is experienced. Some of them have been known to run 20,000 miles without ever being taken out.

With regard to (*d*). It is quite true that the P.Ch.E. produces a very great degree of turbulence by the action of the great and rapid rise in pressure in the chamber on ignition, and the very restricted passage through which the burning gases have to pass. The most efficient chamber in this respect is undoubtedly the Mercedes Benz engine ; the Acro type of head appears to be prone to a smoky exhaust and poor fuel consumption.

It therefore seems abundantly clear that the direct injection engine is superior in every direction and has great advantages over the chamber engine. But undoubtedly it is more difficult to make and requires a special knowledge of how to combine the many important points already mentioned. The chamber engine is a compromise—an easy way out of a difficult job—and for this reason may possibly predominate eventually in the general aggregate, until the gradual rise in the price of fuel oil (which is bound to take place), increases the need for stricter economy, in which case the direct injection engine will undoubtedly take the lead.

The vehicle manufacturers have been practically forced into supplying Diesel-engined vehicles by the insistent demand from their customers. They were thus placed in a difficult position, because none of them had any engineers with any experience of high-speed Diesel design ; in the meantime proprietary Diesels were being turned out rapidly by firms who had the experience but who did not make vehicles. Many of the vehicle makers quickly decided that the best policy was to buy proprietary engines, and so avoid a very heavy experimental and research expense and a great loss of time. Others decided that they would, at any cost, make their own Diesel engines. It has been a very expensive matter for these firms, and in fact it still is so, because at the present moment they still have some long way to go before their

engines will be up to the high standard of those made by Diesel experts. Incidentally and unfortunately, this has entailed a vast amount of bad mechanical failures, smoky exhausts and other troubles, which has, quite obviously, caused a bad impression and has tended to retard the coming of the Diesel engine in this branch of transport. There is a great scarcity of engineers able to design these engines, and therefore a great opportunity open to the many engineering students looking for an opening to-day.

Fuel Oil.

For want of something better, we are still using generally the imported distillates known as "gas oils" or "solar oils," and some blends of these oils with heavier fuel oils. These oils are being sold at approximately 4d. to 4¼d. per gallon, with 1d. excise duty now added, making about 5d. to 5¼d. per gallon in 500 gallon bulk lots delivered. This is much less than half the price of petrol, and our engines will run more than twice the miles per gallon as compared with petrol, so that there is no argument about it—at the moment we are "on velvet." Long and hard experience tells us that we cannot expect to remain "on velvet" for ever. It is up to the transport men to "make hay while the sun shines." For some years past the price was only 4d. per gallon, and those who did not take advantage of this opportunity have only themselves to blame. What is very certain is that there is no hope of a reduction in price, but quite a possibility of a rise, although this will probably be very gradual and in proportion to the increase in the number of Diesel vehicles on the road and the consequent reduction in the demand for petrol.

Many of us had hoped that there would be available soon a supply of home produced fuel oils. My investigations, however, I regret to say, lead me to believe that this is not so, and the chances at the moment seem to be remote. At the same time the information available appears to be conflicting. Mr. K. Gordon, of Imperial Chemical Industries, for example, writes to me that his company do not intend to market such a product, and in any case the Billingham plant will not be in operation until 1935. Yet in his paper to the World Petroleum Congress recently he gives the specification of a paraffinic-naphthenic diesel oil, which can be produced by the hydrogenation process and which would appear to be quite a good and suitable oil for these engines. He says in the paper that: "There is no doubt that further research, especially on catalysts, will produce an improvement on even *this good Diesel oil*." One can only surmise that, although they can evidently produce a suitable oil, the cost of production would be too high and therefore uneconomical in competition with

imported products. On the other hand, Dr. Donald A. Howes, in his paper to the World Petroleum Congress on "Substitute Diesel Fuels," tells us that : "Coal-tar oils of aromatic nature are unsuitable for use in Diesel engines on account of their high ignition temperatures and long delays between injection and ignition." He says : "This eliminates any possibility of utilising coal-tar oils, creosote, etc., *and all other aromatic oils produced by high or low temperature carbonisation or hydrogenation of coal.*"

He also quotes figures to show that by the hydrogenation process the costs of production will be too high to be able to compete with imported oils. He says : "Coal is practically ruled out as a raw material for the production of satisfactory diesel oils by carbonisation or hydrogenation processes."

This is a sad blow in many ways—particularly to the coal industry and also from the National point of view. If there is ever another catastrophe like 1914–1918, the Diesel engine will most assuredly play an important part, and as far as we are concerned we shall still be dependent on our fuel oil having to be brought 3000 or 4000 miles by sea, and we know well what that means. I for one firmly believe that in due course our chemical technologists will be able to find a method of either treating aromatic coal oils to bring them into line for ignition temperature and smooth running, or of finding a new process, possibly somewhere between low temperature carbonisation and hydrogenation, which will give us reasonably good Diesel-engine fuel from our own splendid and abundant coal deposits, but it must be at a competitive price. Another possible source of home produced fuel oil is from Scotch shales, and Dr. Howes gives a specification in his paper of an oil produced from Scotch shale which appears to be most suitable—the spontaneous ignition temperature is only 6° C. above that of a paraffinic petroleum distillate. The oil mentioned was quoted by Messrs. Le Mesurier and Stansfield in their valuable paper on "Fuel Testing in Slow and High-Speed Diesel Engines,"[1] read before this Institution.

This possible source of home produced fuel oil appears to be one well worth investigation, and it would appear that the cost of production might well be such that the selling price might be competitive with that of imported oils.

The question of "ignition qualities" of fuels for these engines has been fully and ably dealt with in the following papers recently read at the World Petroleum Congress :—

(1) "The Measurement of Injection Engine Fuel Ignition Properties." By A. W. Pope.

[1] *J. Inst. Petr. Techn.*, 1931, **17**, 387—418.

(2) "The Desirable Characteristics of Fuels for High-Speed Compression-Ignition Engines." By J. Kewley.
(3) "The Ignition Quality of Fuels for Compression-Ignition Engines, and Proposals for its Determination." By R. Stansfield.
(4) "Measurement of Ignition Qualities of Diesel Fuels." By Dr. A. E. Becker and N. R. Stacey.

In these papers there is much valuable information on the subject, which should be of the greatest assistance to engine makers in advancing the study of how to produce a noiseless and smokeless high-speed Diesel engine for road transport.

The most urgent and most important need is for a smokeless engine under all conditions. There is no doubt that smoke is mostly due to four causes :—

(1) Badly designed engines and sprayers—therefore imperfect combustion.
(2) Lubricating oil getting into the combustion space.
(3) Bad fuel oil or dirty fuel oil or both.
(4) Dirty sprayers and engine out of tune.

Although some of these causes are easily avoidable, there will always be transport users who neglect their engines—it always has been so and always will be. Therefore, there will always be smoky exhausts, unless—even at the expense of thermal efficiency—we can find a fuel oil which is less liable to smoke under inefficient combustion conditions. We shall have to find it, and even pay more for it, because we shall be forced to it.

Maintenance and Advantages.

Advantages of the Diesel as compared with the Petrol Engine.—The "gas oil" or distillate mostly used as fuel for these engines has a specific gravity of approximately 0·860—this means that for each gallon used we have about 1·3 lb. in weight with its corresponding amount of heat units more than we have with a gallon of petrol, which to-day has a specific gravity of about 0·730. So that, taking for example the fuel tank of a 6-ton lorry with, say, 30 gallons capacity, we have an advantage of about 39 lb. in weight of fuel and about 760,000 heat units in addition to the great economy in miles per gallon—in this case about 16 as against 6½ to 7. This type of lorry doing about 500 miles per week, need only fill his fuel tanks once a week, a great saving of time.

Another very great advantage is that in a multi-cylindered engine, no matter how many cylinders there are or how far away the end cylinders are from the pump, the amount of fuel delivered to each cylinder is exactly equal. Those who have had to design

manifolds and fuel systems for 6- and 8-cylinder petrol engines will appreciate the great value of this point.

The entire elimination of carburetter, magneto and spark plugs is not only a great advantage but a great saving in maintenance costs—I refer here to direct injection engines mostly, because pre-chamber engines do require heater plugs and heavy batteries and starters, which result in costly maintenance. With a well-designed direct injection engine, the cooling fan can be eliminated—it is not required—in fact, it is generally necessary to blank off a part of the radiator to keep the engine warm enough. This is another help in reduction of maintenance costs.

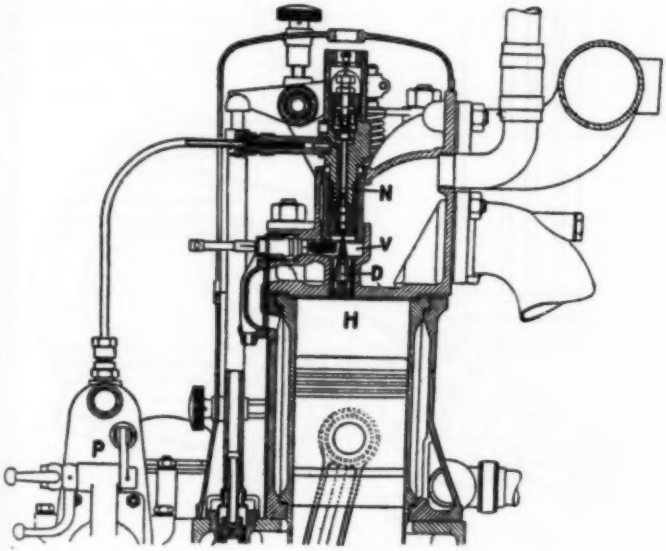

FIG. 6.

SECTION OF CYLINDER-HEAD MERCEDES BENZ PRE-CHAMBER ENGINE.

This again—the cool running of these engines—results in cooler exhaust valves and extraordinary life of these valves. It is a common thing for these valves after 20,000 miles running to be found almost like new. Here, again, is a considerable economy in maintenance. Violent extremes of heat and cold in the radiator are also avoided.

The inlet valves being open to the atmosphere, on the suction stroke the engine is not required to act as a fuel pump to draw

in the mixture through restricted passages, as in the case of the carburetter engine.

The fact that maximum speed is controlled most certainly tends to a longer life of cylinders and pistons, although of course somewhat offset by the higher pressures obtaining. Cylinder lubrication is also carried out under better conditions owing to the cooler engine and controlled maximum speed. With regard to cylinder wear—although perhaps there has not yet been sufficient time for really prolonged test results, we have nevertheless now some very useful

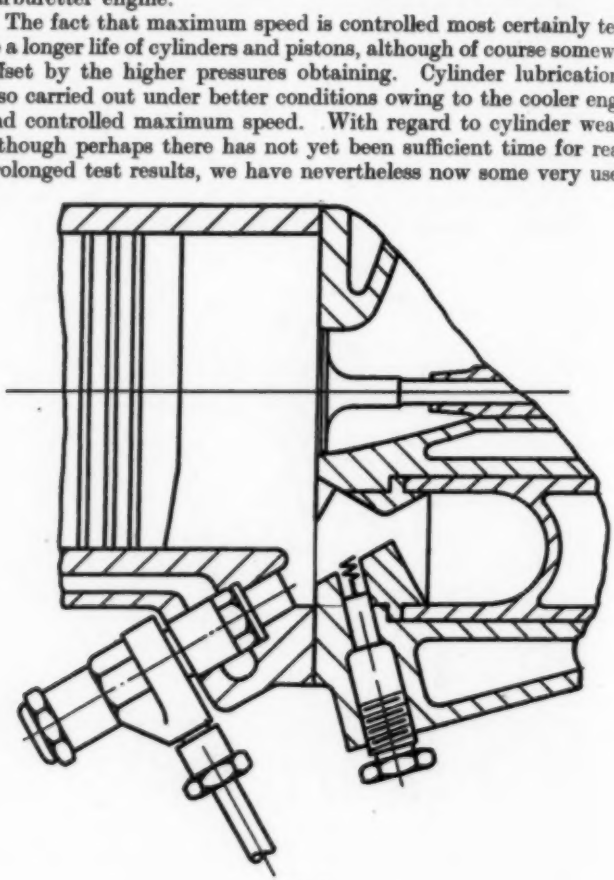

FIG. 7.
THE "ACRO" AIR CELL HEAD.

data on this subject. The greatest wear, very naturally, is found to be right at the top of the cylinder for about $\frac{3}{8}$ in. to $\frac{1}{2}$ in., where of course the top ring gets the full force of the power stroke. Results have varied greatly, but it would appear that maximum wear at this point (right at the top) is about 1/1000th inch for

3500 miles, to 1/1000th inch for 5000 miles generally. There have been cases of 1/1000th inch for 10,000 miles run.

In the centre of the cylinder the wear is about 1 to 1½ thousandths of 1 inch for 35,000 miles. For cast iron cylinders without liners one can say that at least the Diesel can hold its own with petrol engines for cylinder wear, if not beat them.

There are to-day various makes of extremely hard wearing liners being used in petrol engines—it is said that they will run 100,000 miles—but this is still a matter of controversy and in the case of the Diesel we have not yet had time to test these out. With the best designed Diesel engines, also, the wear in the main bearings and big-ends can be truthfully said to be no heavier than those of a well-designed petrol engine. The author has regretfully to admit that there is an impression prevalent in the motor industry that these engines are very heavy on maintenance costs and that pistons and big-ends especially give a great deal of trouble.

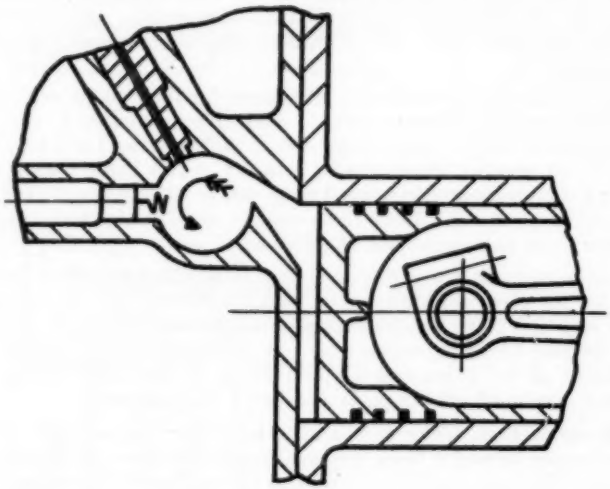

FIG. 8.
THE RICARDO "COMET" HEAD.

This unfortunate impression has been brought about by the many failures already mentioned, which have undoubtedly made many transport managers nervous and doubtful about adopting these engines. This particularly applies to municipal and corporation transport managers, whose every action is watched and

criticised by the public in their particular town or city. However, as a result of hard knocks and expensive experience, the poorer engines are gradually being improved and the bad impressions gradually fading out.

Engines.

The motor transport users in this country are peculiarly persistent in adhering to the orthodox engine—*i.e.*, the 4-stroke cycle engine. Two-stroke engines, for example, have never become popular here, and in the case of the Diesel we have only one normal example —*i.e.*, the Petters engine. The famous Junkers opposed piston engine, also 2-stroke—very popular on the Continent—is not much known here, although there are a few examples on the road. All the rest are 4-stroke engines. Leylands make a 6-cylinder engine 8·1 litres capacity—direct injection—speed range 350–1800, giving 87 b.h.p. at maximum speed. Bosch equipment, A.E.C. make a 4- and a 6-cylinder engine. The latter having 8·85 litres capacity—Ricardo chamber head—16 : 1 compression ratio. Speed range 300–2000 with 128 b.h.p. at maximum speed. Bosch equipment.

Armstrong Saurer make two oil engines for their goods vehicles, as follows: *Six-cylinder engine*; 8·533 litres capacity; $16\frac{1}{2}$: 1 compression ratio; speed range 400 to 2000, giving 110 b.h.p. at maximum speed. *Four-cylinder engine*; 5·702 litres capacity; $16\frac{1}{2}$: 1 compression ratio; speed range 400 to 2000, giving 70 b.h.p. at maximum speed. Both these engines employ the Armstrong-Saurer cross flow principles of injection.

Dormans make three different sizes of 4-cylinder engines, from 3·0 to 5·4 litres capacity, speed range 400–2500 for the smaller size and 400–2200 for the larger sizes, the power outputs being 48, 58 and 75 b.h.p. respectively. A 6-cylinder engine having a capacity of 8·1 litres and a speed range of 400–2200, giving a power output of 110 b.h.p., is also being manufactured.

Mercedes Benz make a 6- and a 4-cylinder engine both with the famous Mercedes Benz pre-combustion (the true pre-chamber) head. The larger engine 8·5 litres and the smaller 3·7 litres capacity —the larger engine gives 95 b.h.p. at 1650 r.p.m. and the smaller 55 b.h.p. at 2000 r.p.m.—Bosch equipment. The small engine has 17 : 1 compr. ratio—the highest used here or elsewhere, it is believed. Apart from the Gardner engine, these four are those which are mostly in evidence on our roads to-day and are typical examples as far as number of cylinders, speeds, b.h.p. and capacity are concerned, of what we have been using so far—*i.e.*, for all the larger type of vehicles—lorries and buses.

THE "JUNKERS" OPPOSED PISTON 2-STROKE ENGINE.—FOUR VIEWS.

FIG. 9.

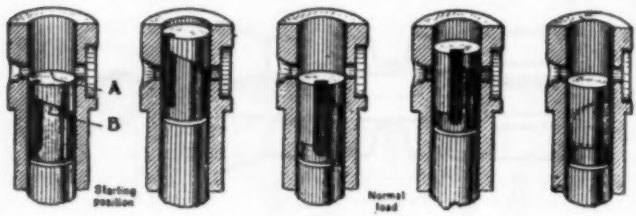

FIG. 10.

SECTION OF BOSCH PUMP BARRELS AND PLUNGERS.

The Gardner Engine.—The Gardner engine occupies a unique position. Gardner Marine Diesels are famous all over the world, and have been so for many years. The Gardner road transport engine is fast following the lead of its marine brother, and is now to be seen in most parts of the civilised world. This road engine was developed from the smaller type of Gardner Marine 4-stroke high-speed engine—a series known as the "L.2" engines, with maximum speed of 1300 r.p.m. There are in fact many of these "L.2" engines actually fitted to road vehicles and very satis-

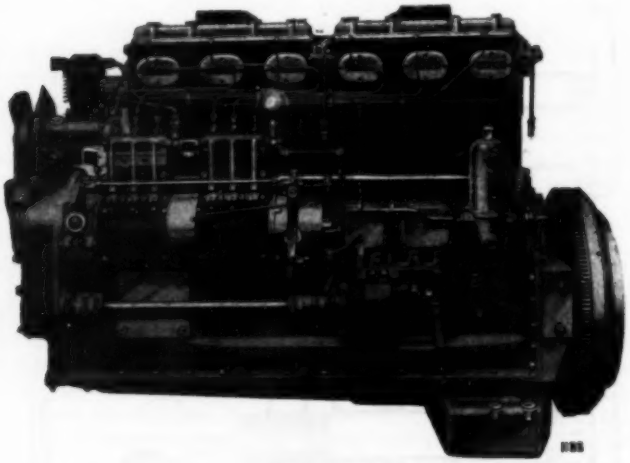

FIG. 10A.

THE GARDNER 6-CYLINDER ENGINE. 102 B.H.P. AT 1700 R.P.M. CAPACITY 8·4 LITRES.

factory they are. One of them ran 105,000 miles in 2½ years (pulling a 12-ton load mostly) without overhaul. Then came what is known as the "L.W." type, a real road motor engine with a

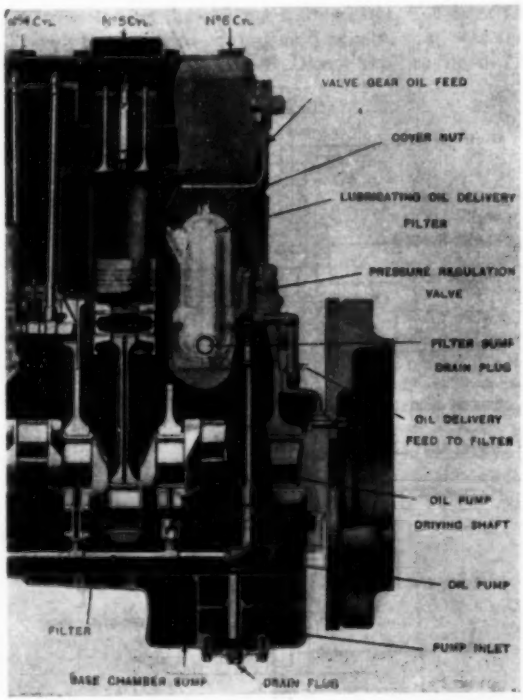

FIG. 10B.

A PARTIAL SECTION OF THE GARDNER SIX L.W. ENGINE.

maximum speed of 1700 r.p.m. This is now made in sizes of 3-, 4-, 5- and 6-cylinders, with b.h.p.s of 51, 68, 85 and 102 respectively and capacities of 4·2, 5·6, 7 and 8·4, and R.A.C. rating of 21·7, 29, 36·5 and 43·5 respectively. This forms a complete range covering all types of vehicle from 3½ tons load up to the largest lorry ever made. The latter being the famous 100 ton lorry which does such extraordinary jobs—recently it

carried a transformer weighing 120 tons across London. This lorry is fitted with the 6-cylinder Gardner engine, 102 b.h.p.

All of these engines—of both series—have standard cylinders of $4\frac{1}{4}$ in. $\times$ 6 in. bore and stroke and aluminium alloy pistons. They start immediately by hand alone in any weather, and have been

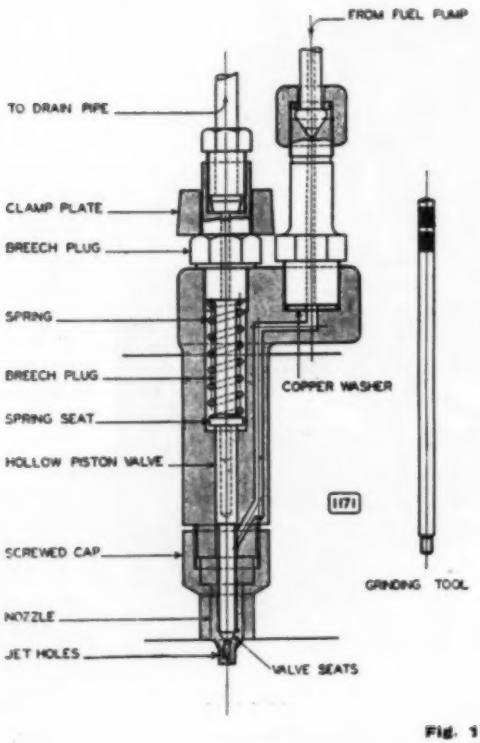

FIG. 11.

SECTION OF GARDNER SPRAYER.

extraordinarily successful everywhere, and in every class of vehicle. There are to-day between 1400 and 1500 of these engines on the road—including both series—of which perhaps 150 are abroad. There are 110 in China, all fitted to buses of one company. One railway company here has approximately 150 running, and many

firms have fleets of them. From the British engineering point of view an outstanding achievement is that no less than three very important Continental firms have recently concluded arrangements with Messrs. Gardners for manufacturing these engines under licence—in Belgium, France and Holland. It is interesting to note that in each case these firms have stated that after trying out all the known Continental engines and others, they were convinced that this was the best high-speed Diesel yet produced. We may

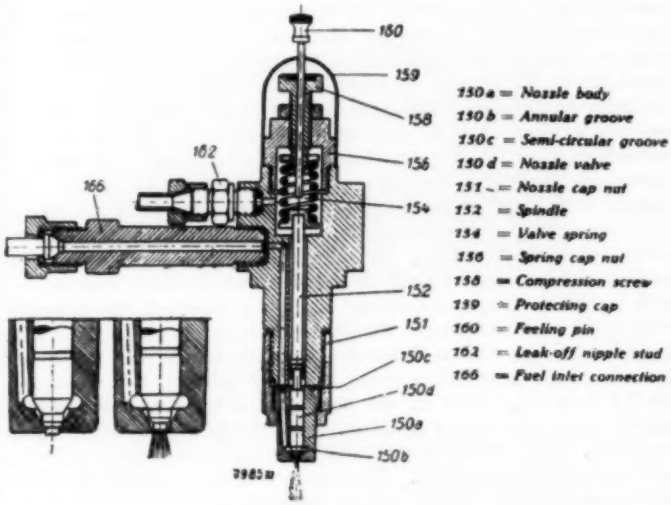

FIG. 12.

SECTION OF BOSCH SPRAYER.

here bear in mind that most of the Continental engines are of the chamber type of head—therefore a convincing argument in favour of the direct injection engine. The main points of the Gardner engine are its extraordinarily low fuel consumption—0·365 lb. b.h.p. hour, the lowest yet achieved in this class of engine ; its low compression ratio =13 : 1, also the lowest known ; its simplicity and great reliability, its immediate hand-starting from cold—high B.M.E.P.—and sound construction. The only parts not made here are the injection pump plungers and barrels, which are made by R. Bosch and Co. ; the rest of the pump and the governor are Gardners' make, as also the sprayer, which is extremely simple and very reliable. Another outstanding point is entire elimination of

fuel dilution, enabling the engine to run big mileages on lubricating oil—from 1500 to 2000 miles per gallon is now being obtained.

Speed of Engines.

Although there are a few isolated examples of engines running above 2000 r.p.m., the majority are set to a maximum speed of from 1500 to 2000 only. It has been undoubtedly proved in actual practice that it is necessary to limit these engines to a maximum governed speed if we wish to avoid smoke and many other troubles, and a poor fuel consumption. It is significant that both Gardners and Mercedes Benz—the two most experienced makers—limit their maximum speed to 1700 r.p.m. and 1650 r.p.m. respectively, at least in the larger sizes. For engines of 5 litres capacity and over it seems that 1700 r.p.m. is about the limit, if we are to keep to ideal combustion conditions. This is no disadvantage—on the contrary, it is a great advantage—maintenance costs are kept low and lubricating conditions are good. By taking advantage of the high torque of the Diesel at all speeds and using proper gear ratios we can get all the road speed we want—and more. Figs. 13 and 14 show the latest Diesel-engine chassis, made by the Gloucester Carriage and Wagon Co., and in which proper advantage has been taken of the powerful torque of the Diesel and the gears designed accordingly. This chassis is fitted with a Gardner 6-cylinder engine and a 5-speed gear box, the gear ratios being 3·55, 4·8 (direct), 8–1, 16–1 and 30·7–1 forward. That is, the fifth gear is an over drive, which allows the coach to run at 27 m.p.h. with the engine revolving at only 850. This ensures comfortable cruising at the most economical and quietest engine speed. This again reflects to advantage in the fuel consumption, which is most astonishingly good. There are six of these coaches at present running between S. Wales and London, and the average consumption is approximately 18½ m.p.g., with a total gross load of 8 ton 9 cwt. This results in the high figure of 151·3 gross ton miles per gallon—easily a record for Diesel passenger work. The maximum speed of this vehicle is 54 m.p.h., well above the legal limit. This is believed to be the first chassis that has been actually and specially designed all through for a Diesel engine. Its fuel tank capacity allows for a run of 710 miles.

The Budget Proposals for Commercial Vehicle Taxation.

A study of the new taxation for commercial vehicles, which if passed into law as one expects it will be, comes into force on January 1st, 1934, cannot fail to leave the impression that the Diesel engine has been favourably treated. Fortunately the figures proposed by the famous Salter Committee were drastically

reduced. It is also significant that while the duty of 8d. per gallon still remains for petrol, only 1d. per gallon has been put on heavy oils. One may reasonably form the opinion, then, that the authorities are inclined to encourage the coming of the Diesel engine.

FIG. 13.

GLOSTER-GARDNER COACH. 102 B.H.P. ENGINE. 54 M.P.H. 18·5 M.P. GALLON.

FIG. 14.

CHASSIS OF ABOVE, SHOWING THE GARDNER 6-CYLINDER ENGINE.

For lorries, the scale of duties is based on the unladen weight and rises with each ton increase in weight—up to 10 tons unladen weight, and there are very few above that weight. As an example of the actual position as it will be on January 1st next, we may take the popular type known as a 5-ton lorry—this comes into the category of 4–5 tons unladen weight. At the present time this lorry (on pneumatic tyres) pays £43 yearly tax, *i.e.*, with a petrol engine—the Diesel, of course, now pays *no* extra tax. On January 1st this lorry will have to pay £70 tax if fitted with a petrol engine and £90 if with a Diesel engine. That is, it is penalised £20 for the Diesel engine. But taking a year's mileage as 30,000 (an average run for this type of lorry), the fuel bill will be about £312 in the case of petrol and only £39 in the case of the Diesel. Thus while we lose £20 on the tax, we gain £273 on fuel, leaving us £253 to the good. Although the very heavy lorries are heavily taxed, the gain, as in the above case, is approximately proportional. An attractive proposition for any transport firm. In passenger work the vehicles are taxed in seating capacity only. The double deck bus, for example, with 48/56 seats, to-day pays £86 8s. yearly tax. On January 1st this bus will have to pay no extra for petrol engine, but has to pay £61 12s. for a Diesel engine extra. On a 40,000 mile run (which is an average bus mileage), this bus can save £250 nett per year, after allowing for the extra Diesel tax.

Progress on the Continent.

On the Continent, especially in France, greater progress has been made than in Great Britain with the Diesel engine on the road. In Germany also great progress has been made.

Nearly all the well-known motor-vehicle manufacturers in France now produce Diesel-engined vehicles, amongst them being such well-known names as Renault, Panhard, Berlet, Unic, Somua, Delahaye, Bernard, Rochet-Schneider, Comp. Lilloise and others. Also there is a French-built Fiat design, and Mercedes Benz engines built under licence by French makers. The Gardner engine also is now being made in France under licence.

Gas oil in France is dearer in relation to petrol than in this country, the French Government apparently being desirous of fomenting alcohol as a fuel rather than encourage the Diesel. In spite of this, the progress made is very rapid. On a recent journey by road all through France the number of Diesel lorries observed was most astonishing, in the south especially; in the wine districts at least 80 per cent. were Diesels.

Smoky exhausts were too much in evidence also, some being very bad indeed, and this in spite of the fact that almost all of them were pre-chamber or air-cell engines.

At this moment the French are holding their important Motor Exhibition, which includes commercial vehicles, and, according to information available, oil-engined vehicles will be the leading feature of the Show.

World Wide Demand.

These engines are now being sent to all parts of the world, and enquiries continue to come in faster than ever—some from places where one hardly thought that road transport existed.

It is curious to note that in America progress is slow. There are one or two engines available, but generally there has been very little done. One reason is, of course, that gasoline is very cheap, and the other is that these engines cannot be made on the mass production system. It may be, of course, possible that Mr. Roosevelt will give orders for everyone to turn over to Diesel engines, to help in his great "return to prosperity" campaign.

What of the Future for this High-Speed Diesel?

The answer to this, bearing in mind what has been achieved in the short space of three years or so, is that its future must be brilliant. The high thermal efficiency, the extraordinary torque range, simplicity, ease of starting, elimination of magnetos and carburetters, low maintenance costs due to governed maximum speed, freedom from the danger of fire both in garages and on the road can only have one result—its general acceptance and the gradual elimination of the petrol engine. It is only yet in its infancy, but this infancy is a very healthy one. It will come to perfection in far less time than was the case with the petrol engine, especially if the chemists lend a willing hand on the fuel side; we need this co-operation.

There are competitors, of course, and there always will be. Coal gas, for example, is now being tried out, highly compressed in steel cylinders, carried under the chassis. The weight of these, and the difficulty of carrying sufficient gas for a long run, and the danger are all against this form of fuel, and the economy obtained is not great enough to make it worth while.

There are various forms of bi-fuel vaporisers now on the market, and some of these have been tried out for years, but not with any marked success. Fuel dilution is serious and the effect on the engine is unfavourable. And again here the economy obtained is too small to be worth while: it is a poor and messy compromise.

The high-speed Diesel has passed through its testing period with flying colours, and is undoubtedly the engine of the future for road transport.

DISCUSSION.

The President said that all present would agree that they had listened to a fascinating and highly important paper. The experience gained in the past 3½ years seemed to bear out very fully the claims made by the author in his earlier paper.

The principal advantage of the Diesel engine over the petrol engine seemed to lie in the present relatively very low cost of fuel, but the one certain way of reducing that advantage would appear to be to put more and more Diesel engines on the road.

They were glad to have with them that night many visitors, or rather guests, and he hoped that they would participate in the discussion, which would be opened by Mr. Le Mesurier.

Mr. L. J. Le Mesurier observed that the paper was of a practical nature, as one might expect coming from Major Goddard, who had had a very great deal of experience in furthering the Diesel engine for transport purposes and in converting petrol vehicles into Diesel vehicles.

The impression obtained from a brief study of the paper was that Major Goddard was a Diesel enthusiast with a very strong leaning towards the direct injection engine. Major Goddard had advanced arguments for and against two types of engine—pre-chamber and direct injection—and, according to his view the pre-chamber engine suffered badly in comparison with the direct injection type. Major Goddard had, however, omitted due reference to types of engine incorporating *an air cell* in either the cylinder head or piston and in which the fuel was sprayed into the combustion space. This type of engine is not exactly direct injection but combined features of both types of engine, and due reference to it might have been expected in a paper of this description.

In making these remarks he did not wish the members to feel that he had any bias whatsoever against a direct injection engine; it was a type of engine which he considered gave results at least as good as any other type, but he ventured to suggest that the results should not be expressed in such a way as to indicate an undue superiority over other types of engine.

A considerable portion of the paper was devoted to the problem of exhaust smoke, and he had the impression that Major Goddard was perhaps exaggerating that difficulty. After all, as Major Goddard said, there was a large number of omnibuses running in the streets of London under exceedingly trying conditions, and the passengers did not notice whether they were petrol or Diesel vehicles, which would scarcely be the case if smoke was such a serious problem.

The author referred to the various reasons for exhaust smoke,

and he headed the list with badly designed engines and sprayers causing imperfect combustion. According to his, the speaker's, own experience, there were no reputable engine builders who sent out an engine from their works in a condition where there was a definitely smoky exhaust. Most engines in the test shop run at normal load without smoke. In service, however, the trouble might start from various causes, such as insufficient precautions to maintain the fuel in clean condition or inattention to the fuel sprayers, etc., and he was glad to see that in another part of the paper Major Goddard stressed the importance of periodical examinations of engines. He believed that difficulty with exhaust smoke would be almost eliminated by a well-organised system of control and examination of the sprayers and other parts and proper attention to fuel cleanliness.

Another subject to which Major Goddard had referred was cylinder liner wear, and figures were given showing the liner wear in terms of so many thousandths of an inch per so many miles. Personally, he would strongly suggest that all liner wear measurements should be given in relation to the number of running hours of the engines. The figures given in the paper, if he might say so, were quite meaningless, as in one case they might refer to a 'bus averaging eight miles per hour, and in the other case to a long distance vehicle averaging 20 or 30 miles per hour. Rates of wear based on running hours were, however, comparable and gave a much better indication of what was happening.

Major Goddard referred to engine speeds which had increased from 1300 to 1700 r.p.m. during the period under review, but he believed that there were engines running satisfactorily at still higher speeds. Although Major Goddard suggested later that high speed was not of any particular advantage, it will be necessary to develop towards still higher speeds if the Diesel engine is used in the smaller types of vehicle where the petrol engine runs at speeds of 3000 to 4000 r.p.m.

Mr. R. Stansfield said that Major Goddard had stated that a properly designed engine, kept in proper tune, did not smoke, and had added that the gas oils and the fuel oils generally supplied required centrifuging before use. He had mentioned a case where one fuel had led to choked sprayers and to smoke in three or four days, while another fuel of the same type had run smokelessly for five weeks.

A distillate fuel could not help being quite clean when it left the point of manufacture, and any dirt which got in did so only between the refinery and the engine fuel tank.

The oil companies were very well aware of the grave difficulty which arose when fuel was dirty, and they took every precaution

to deliver clean fuel to the user; but how far that cleanliness was maintained after the fuel reached the user was quite another question. There was considerable evidence that only a minority of the people handling Diesel fuels appreciated at all the need for the cleanest of storage arrangements and for greater care in handling than was necessary with petrol. Dirt which got into petrol would readily settle. Dirt which got into Diesel fuel in a similar way might easily reach the engine without settling out, because of the very much higher viscosity of the fuel in which it was suspended. When fuel was drawn from a small storage tank and that storage tank had just been filled up from a bulk supply, a very large amount of the contaminating matter which had reached the fuel after the point at which it was manufactured was stirred up and might get through even the finest filters into the engine. It was, unfortunately, well known to analysts that gas oils taken from users' tanks often had a great many times as much sediment in them as in the fuel from the bulk supply from which those tanks had been originally filled, and contaminated fuel would inevitably lead to spray valve trouble and to smoke.

Major Goddard mentioned that it was good practice to centrifuge the fuel. That was something which the large user was now doing, but it could scarcely be expected that the smaller user would follow suit; he was not getting through the quantity to justify that treatment.

A regular and very thorough cleaning of both storage tanks and 'bus tanks was indicated each time before they were filled, and the people who were handling diesel fuel must be educated to realise that although it was a cheaper fuel and of a different colour from petrol it required as much or even more care taken in order to prevent dirt getting in. Personally he would venture to say that any two diesel fuels of the same ignition quality would give no detectable difference in a modern high speed Diesel engine as regards sprayer trouble and smoke, except from differences arising because one of the fuels had been allowed to get dirty and the other had been kept clean.

Major Goddard took the smoke question a stage further when he asked for a fuel which, at the expense of thermal efficiency if necessary, would not smoke even under inefficient combustion conditions. Major Goddard was prepared to pay a higher price for such a fuel. Personally he was afraid that that hope could not be realised. An engine in bad condition—an engine which smoked—could be changed over to run on kerosine and yet, even with the good volatility of the kerosine, the smoke would persist. Once the engine had got into bad condition, no change of fuel which one could hope for would cure that smoke. In fact he

would like to re-word the dictum that : " We shall have to find it and even pay more for it, because we shall be forced to it," and to say instead : " We, the engine makers and users, shall have to find means for keeping the fuel clean, and even pay for doing so, because we shall be forced to it."

In addition to mechanical impurities in fuels, cases had occasionally arisen in which certain types, having a high organic acidity, had been stored in zinc-lined drums and had dissolved some of the zinc coating. Fuels such as those, after being stored in galvanised-lined drums for some time would build up " carbon " on the spray nozzles, and as much as 50 per cent. zinc oxide had been extracted from that carbon build-up. A fuel of the same type, which had not been stored in contact with zinc, would leave a perfectly clean nozzle under the same running conditions. He mentioned that point because the use of the galvanised storage tanks was useful to prevent troubles due to rust—finely divided iron oxide—getting into the fuel and acting as an abrasive on reaching the engine. If galvanised tanks were used, it would be necessary to select fuels which had not a solvent action on the lining due to the presence of, say, naphthenic acid.

Mr. A. J. Wilson said he desired to ask one question on the dilution of lubricating oil. Everyone knew that no engine would run unless efficiently lubricated, and the astonishing experience which he had recently been through with the types of lubricating oils manufactured by different makers had led him to the opinion that experience in dilution was going to be the decisive factor in selecting a lubricant for a particular type of Diesel. Would Major Goddard state whether he had found a greater dilution in the pre-chamber type of engine than was obtained in the direct injection ?

Dr. V. Henny remarked that the author had drawn attention to the nuisance of diesel fuel and had mentioned how, in one of the Northern towns, people were having to move out of their houses on account of it. He remembered a similar statement by a French expert (M. Audibert[1]) about high-speed Diesel engines, and because Major Goddard had stated that France was ahead of this country in Diesel construction, he had looked up that statement. Therein were mentioned the great drawbacks of Diesel engines, especially high-speed Diesel engines, in France, referring especially to the most unpleasant odours which emanated from them, and adding that the only way to suppress those fumes was to use a special diesel fuel. Everybody knew the extra cost which would be involved in using such a special diesel fuel, and therefore

[1] *Ann. des Comb. Liq.*, 1933, **8**, 385–449.

the present main advantage of the cheapness of the fuel would soon disappear.

Mr. E. A. Evans said that one could not dissociate the subject of fuel economy with the high-speed Diesel engine. One naturally asked how long was it going to last? Surely it would depend in a large measure on the legislature. From the figures given it would appear that the actual production cost of the diesel fuel was roughly twice that of petrol. The major difference between the cost of diesel fuel and the petrol was due to Excise Duty. Against the difference in production cost it would be argued that a gallon of diesel oil would carry a vehicle a much greater distance than a gallon of petrol. It would be interesting to restate the consumption figures on the weight of oil consumed and on the calorific value of the two fuels.

Much had been said in other places about the actual supply of fuel for the high-speed Diesel engine. There seemed to be a certain amount of anxiety felt for the future if all petrol engines were to disappear and were replaced by Diesels. Doubtless Major Goddard had considered that point and discussed it with the large supply companies.

Major Goddard spoke about the necessity for research on diesel fuels. We have been told in the past that the Diesel engine is much more "fussy" about its fuel than was originally supposed; in fact we are told that the only method for determining the suitability of a fuel was to try it in the specific engine which had to be used.

Dr. Howes said that aromatic hydrocarbons made unsuitable fuel. Possibly the suitability of some fuels is traceable to the aromatic content.

He was very glad that Mr. Stansfield referred to centrifuging of the fuel oil, because it did seem difficult to understand how an engine could possibly run with a fuel orifice which was measured in ten thousandths of an inch if the oil had to be centrifuged before use.

In the past we have experienced a lot of trouble with dilution, but from the large number of tests made in his laboratory on all kinds of Diesel engines it is quite obvious that the Gardner engine does not suffer badly from this defect nowadays.

With regard to the Bentley car which had run on the Monte Carlo trials, Major Goddard said that there had been no difficulty in starting the engine at −25° F. That was very cold, and one could only express wonderment at the ease with which the drivers overcame the resistance of the frozen lubricating oil in the engine. It must not be forgotten that the oil in the steering gear had

frozen pretty hard. Possibly the author may remember a very similar experience in Sweden some years ago, when we were told that no difficulty was experienced in starting the engine at –60° C. The secret of the easy get-away apparently was due to a special fuel spray fitted to the cylinders which were put into operation before the engine was turned. Also a very thin oil was used which was only run for very short intervals.

Dr. E. R. Redgrove asked Major Goddard whether, in his experience, the question of smoke and the dilution of the lubricating oil was not purely one of the degree of combustion of the fuel, which depended almost entirely upon the degree of atomisation, which in turn depended mainly upon the design of the jet, the nature of the fuel pump and the condition of both ?

Major T. R. H. Garrett said he desired to ask what was the weight per b.h.p. of the best Diesel engine ? Could it be got down to anything below two or two and a-half pounds for aeroplane work ?

Mr. A. Lampert remarked that a statement was made that direct injection engines dominated the market. Personally he had to differ from that view. It was actually a fact that there were close on 5000 Diesel engines running of the ante-chamber type. As a matter of fact, on the Continent and in England, of one make alone, there were over 3000 of such engines in operation which had covered an aggregate mileage of some 120 million miles —some 10 million miles per month. Surely that proved that the chamber engine had gone a good deal further ?

Mr. Rowntree drew attention to the statement: "No time wasted in warming up and starting from cold," and remarked that surely there was just as much necessity to give time for lubrication circulation as with the petrol engine, hence the question of fumes in garages would be just as great a *disadvantage*, it being accepted that all engines, whether C.I. or I.C., need a period of relatively "fast idling" to allow the lubricating oil properly to circulate to all vital parts before the engine is put on load.

Mr. W. H. Goddard, in a written reply, said that, in reference to Mr. Le Mesurier's remarks, the air cell engine appeared to be going out in this country as only one firm was now making it. The inventor of the original air cell engine has now brought out a vastly different design which it is assumed is to replace the original design.

It is certain that there have been put on the road some engines which were apparently incurable as regards smoky exhaust, and these have been the cause of serious trouble. On the other hand, smoky exhaust is often due to carelessness, lack of attention, and dirty fuel.

In the commercial motor world liner wear is always given in so many thousands of an inch per so many miles run regardless of the load or speed, but when such a subject is under discussion the type of vehicle is always considered and the comparison made clear.

The smaller Diesels now being made will undoubtedly be run at higher speeds, owing to much lighter reciprocating parts which will result in reduced stresses.

The information given by Mr. R. Stansfield is of great value and it is interesting to learn that organic acidity may attack the zinc lining of drums and thus cause trouble with sprayers in the engine. The frequent cleaning of storage tanks is therefore to be recommended, and the oil should be centrifuged where possible.

With regard to Mr. A. J. Wilson's remarks, until recently most direct-injection engines caused dilution in the sump, while the reverse was generally the case with pre-chamber engines—i.e., the sump oil thickened. This thickening was probably due to colloidal carbon. It now seemed that dilution troubles were generally diminishing, and more particularly so in the case of one direct injection engine in which a new type of sprayer nozzle had almost eliminated it. It is evident that, in this type of engine, it is a matter of design of sprayer in combination with injection pressure.

He was glad to see that Dr. Henny confirmed his contention about smoky exhaust trouble in France. It is one which will most certainly have to be curtailed.

In reply to Mr. E. A. Evans, he would point out that after 5½ years without any tax on diesel fuel the Government had now imposed a tax of 1d. only per gallon. As the number of diesel vehicles increased it was reasonable to assume that the tax would also increase. The value of a diesel vehicle should, however, not be calculated on this variable item, but on its high thermal efficiency, the latest figure for which is 38.7 per cent. Consideration should also be given to its capacity for consuming fuel nearly in proportion to its load over its useful power range.

The figure of −25° F. in the Bentley car trial is taken from Lord de Clifford's report published in the Press, and there is no reason to doubt its correctness.

In reply to Dr. E. R. Redgrove, a well-designed direct injection engine, in good order, will not emit smoke and the dilution is negligible, assuming that good clean fuel is employed.

In regard to Mr. A. Lampert's remarks, in his statement as to the domination of the market by direct injection engines he had been referring to England. He had stated in the paper that in France most of the engines were of the pre-chamber type, but in England the direct injection type was predominant.

A vote of thanks to the author of the paper concluded the meeting.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

FIFTEENTH ANNUAL DINNER.

THE FIFTEENTH ANNUAL DINNER of the Institution of Petroleum Technologists was held at the Connaught Rooms, Great Queen Street, London, on Friday, October 6th, 1933, Mr. Thomas Dewhurst, President, occupying the Chair.

"The King."

The Toast of "The King," proposed by the President, was received with musical honours.

"The Petroleum Industry."

Engineer Vice-Admiral H. A. Brown, C.B., who proposed the Toast of "The Petroleum Industry," said that he felt it a great honour to be allowed to propose the Toast and to add his small pæan of praise to the somewhat inadequate applause which the industry normally received from the general public. Furthermore, he welcomed the opportunity of expressing the gratitude of the Royal Navy for the way in which their demands for the products of the industry had always been met. There might be a certain amount of complaint as to the unreasonableness of those demands, but the petroleum industry was always open to conviction in the light of naval experience. For example, if one were on the bridge of a destroyer with a following wind and had too much sulphur in one's fuel, one was not very pleased with the oil industry. (Laughter.)

Before coming to the subject of the Toast he would like to show that he had some qualifications for proposing it, other than that of the high office which he had the honour to hold. As far back as 1903 he spent very many weary hours trying to burn oil in an old vessel called the "Sultan," one of our earlier experiments which led to the fairly satisfactory results obtained at the present day. In 1906 he was present at some of the trials of our first all oil-burning vessels, the coastal T.B.D.'s, always known as "the oily wads." In 1913 he had the honour to be Secretary of the Committee known as the Standing Committee on Liquid Fuel, which in one of its first reports recommended the establishment of an oil refinery in this country. That refinery was now, he understood, going in fairly full blast. Appended to the report, when he looked it up, he found a chit from the Chairman saying: "This may be what the Secretary thinks, but it is not what the Committee said!" (Laughter.)

He did not know that he had anything further to add with regard to his personal qualifications, except that he had probably

burned or wasted more oil under boilers, either personally or by supervision, than anyone else present that evening. Whether that was a qualification was hardly for him to say (laughter), but it had certainly helped towards performances that would otherwise have been impossible.

To propose the Toast was a somewhat difficult task, not because it was not easy to say pleasant things about the oil industry, but because it was difficult to know exactly what to say. He would like first to mention that for four years he was in the United States, and there had what Mr. Weller would call "waried" experiences, which ranged from assisting a hobo to cook his midday meal by burning oil in the simplest possible way, by plugging a hole in the bottom of a kettle and a few holes in the side—and oil would burn perfectly well under those conditions—to taking a trip with a prospector who assured him that much more money was put into the ground than ever came out of it (laughter); to somewhat unique opportunities of inspecting in detail the wonderful oil refinery plant owned by the Standard Oil Company in New Jersey. His experiences in America, therefore, might be said to have ranged from the ridiculous to the sublime.

He deeply appreciated all that the petroleum industry had done for the Navy and for the country at large, but he was aware that there were certain carping critics who held that what had been done was not for the entire good of the country, in that to some extent the use of certain of our indigenous products had been replaced. Personally, he felt that no blame, if blame there was, could be attached to those connected with the petroleum industry in that regard, because the matter was one of natural evolution which was bound to occur in order to meet modern demands. If it had not been oil it would have been some other form of energy, though he confessed he could not suggest for the moment what that other form of energy would have been. (Laughter.)

The oil industry was now more than a mere industry and might almost be called an institution; and perhaps, with a certain amount of after-dinner licence, a benevolent institution. (Laughter.) He could see that raised a smile, but in support of such a claim cogent reasons could be advanced. The industry was, after all, mainly responsible for making possible that rapid rate of travel which many people thought would do far more than anything else, by allowing free intercourse between nations, to promote the future welfare of the world. (Cheers.) Furthermore, apart from making as much profit as was reasonably possible for the shareholders, the main object of the oil industry was to provide the modern amenities of life for our vast population at the least possible price. He thought for those two reasons the

industry had a substantial claim to be looked on as a benevolent institution.

It had been asserted by many eminent people in the industry, moreover, that the oil industry had no wish to replace what was still our greatest asset, coal, wherever coal could be economically used. He thought there could be no question about that. The oil industry had no wish to see its products used in an uneconomic and wasteful way. He had heard it said by those associated with it, that they were ready to use their vast distributing agencies to help in any way in the disposal of any of the products of coal which could be economically produced.

He thought it was fairly obvious that an industry which had at its head men of the calibre of those who led the oil industry would realise to the full that no one industry had the slightest chance of standing entirely alone. There could be no question that the prosperity of any one industry depended on that of all the others. The motor-car and aircraft industry provided a good example of that. The motor industry had been made possible entirely owing to the products of the petroleum industry, but it was little realised by most people that the motor industry was directly responsible, on a modest computation, for the use of two million tons of coal a year in this country; indeed, the figure was probably nearer four millions. The oil fuel imported was not much in excess of three million tons. That seemed a very good example of the fact that industries did not stand alone and that the oil industry was really of direct help to the coal industry.

It was unnecessary for him, in view of the audience which he was addressing, to explain what a vast and complicated industry the oil industry was; but, as a layman, he would like to voice his personal admiration for all the links in the chain of the industry. For the prospector, and the energy and enterprise tempered with knowledge with which he located new fields, to the financier, who developed them; the chemist, without whose vast knowledge the thousand and one products now indispensable to modern civilisation could not be produced; the engineer, whose skill had made possible the pressures and temperatures necessary; and finally the administrators and organisers, who were able to visualise the trend of public demand from day to day and arrange their products to meet it, and who were able to arrange with uncanny skill that the most worthless waste product of one decade should become the most valuable of the next.

He had recently read in the Press a description in some detail of one link in the chain, that which he had somewhat irreverently dubbed the prospector. He read that the prospector "must be a palæontologist capable of placing the strata he examines in their

approximate stratigraphical position, and he must be a petrologist capable of separating out and identifying the characteristic heavy minerals of the rocks he has to study. Furthermore, he must be a physicist capable of interpreting the results of geophysical surveys, whether gravimetric, electric, magnetic or seismic, even if he cannot himself use the delicate instruments necessary for such investigations. Most important of all, he must know enough of drilling and drilling methods to act as guide, philosopher and friend to the drilling staff. Truly he must be a many-sided man; his responsibilities are great and becoming greater year by year." (Laughter and applause.) If that described one link in the chain, those engaged in the industry must be veritable supermen.

In conclusion, he would like to wish the industry continued prosperity and a continuation of the skill and directing force for which it had always been distinguished. As representing to some small extent the three defence Services of this country, he would like to thank the industry for the way in which it had helped them to obtain performances with all our weapons of war, if need be, that were second to none. It gave him great pleasure to propose the Toast of the oil industry and all connected therewith. (Applause.)

Sir Basil Kemball-Cook, K.C.M.G., C.B., who responded, said that it afforded him particular pleasure to respond to the Toast, because it had been proposed by his old friend the Engineer-in-Chief of the Navy. In the far-off days of the war, Engineer Commander Brown (as he was then) held a position of great responsibility; the transport department used to present him with various missions to inspect engines, many of which, unfortunately, were not in their first youth. He would disappear into furnaces with apparently no chance of ever coming out, but he never let us down.

He would like to thank Vice-Admiral Brown very sincerely for his eloquent speech (applause) and for his presence that evening as a representative of the Admiralty and the Navy. The Senior Service, with that far-sightedness which distinguished those who go down to the sea in ships, had always realised the immense value of petroleum to this country, and had done everything in its power to encourage it.

When he came to refer to the Engineer-in-Chief as the only ostensible representative that evening of His Majesty's Government, however, he did not find his task quite so easy. We had to-day a National Government, which claimed, he believed, to be a paternal Government. So far as the petroleum industry was concerned, he thought the paternity was somewhat doubtful, although he did not wish to suggest there was anything illegitimate about the petroleum industry. (Laughter.) The Government had

undertaken, apparently, to follow the popular fashion and subject the industry to a process of slimming, which was known, he believed, as the survival of the flattest. (Laughter.) He saw an advertisement the other day addressed to the fair sex which said "I guarantee to reduce your figure and your bust." The idea of the Government, it seemed, was to increase its figures until we bust. (Laughter.) There was an old adage about killing the goose which laid the golden eggs. Personally he was not afraid for the bird, but if the Government went on sucking the eggs in the way it was doing the only lucky ones would be those who were able to make a living (however precarious) out of Golden Shell. (Laughter.) All advertising rights were reserved. (Laughter.)

If the taxation to which he had alluded had been imposed entirely for fiscal reasons, the petroleum industry might be prepared to bear it and grin if they could; but the recent imposition of the fuel oil tax had, he was afraid, a different aspect; it was avowedly imposed with the idea of encouraging the consumption of coal in this country to the detriment of oil. There was a tendency to-day in this country, particularly among coal enthusiasts, to regard oil as the bad boy of the family. Most people would have read Mr. Frank Hodges' declaration, "Foreign oil is coal's real enemy and the one which should be attacked over the next decade with the utmost technical and scientific vigour."

He thought those enthusiasts were entirely misguided. It was a profound mistake to treat oil as if it was obstructing in any way the progress of coal. Motor drivers in London might be inclined to think that the boot was on the other leg; how many people, when they had filled up at a pump and had started off down the road, had found their progress impeded by a row of black-coloured waggons drawn by horses and carrying, like the tumbrils of the French Revolution, the innocent subjects of King Coal, wrapped in sacks, to their doom of uneconomic consumption (laughter and applause), butchered, one might say, to make a London foggy day. (Renewed laughter.)

The Engineer-in-Chief had alluded in eloquent terms to the interdependence of those two great industries. It had been in his own mind to cite the very case of the motor and aeroplane industries as those which depended entirely on oil but which consumed great quantities of coal. As a matter of fact, each of those two great industries, oil and coal, had its own place. They should not work against each other; they should work together. He would urge those misguided enthusiasts to whom he had alluded to work for the scientific development of the use of coal and not to waste their energies in attacking petroleum, which was one of their best friends. There were signs that the wiser heads

in the coal industry were turning their minds in that direction, and he would do nothing to belittle their efforts.

He did not propose to say anything that evening about hydrogenation, because his audience would be sick of hearing about it. He would therefore simply say that imitation was the sincerest flattery. He would urge those enthusiasts to make more gas; and when he said gas he meant gas and not hot air. (Laughter.)

Depression hung over the world like a dark cloud, but he did not think that those who were in the petroleum industry had any reason to be too depressed. They had very much for which to be thankful. They had to be thankful for the brains and energy which were shown in every branch of their great industry. In that regard, the Engineer-in-Chief had taken the wind out of his sails; he himself had been intending to give a catalogue of the various aspects of the petroleum industry. He did not think, however, that he could possibly improve on what had been said in that regard, except that Vice-Admiral Brown had not referred to the men of the tanker fleets who carried the oil under such dangerous conditions to the various ports, and, though he mentioned the distributors, he had not emphasised the part played by the salesmen of the industry, who were really its storm troops. When one surveyed all those different bodies of men, all working together in the cause of progress and in the cause of science, one saw no reason to be depressed; and he would conclude by putting a question which he was sure everyone present would answer with the full force of his lungs: "Are we downhearted?" (Loud cries of "NO!" and applause.)

"The Institution of Petroleum Technologists."

Sir Arnold T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O., M.P., who proposed the Toast of "The Institution of Petroleum Technologists," said that it was particularly kind of the President to entrust to him the honourable duty of proposing the Toast of the Institution, to which he himself for many years belonged. (Applause.) He was conscious that he was among old friends; otherwise he would feel somewhat embarrassed at being sandwiched in between the first-class speakers who had preceded him and an experienced and hard-headed parliamentarian. It was scarcely fitting that the latest joined member should open his mouth in the presence of anyone who had secured such a reputation for the accurate presentation of devastating facts as had his friend Mr. Williams.

The admirable speeches to which he had listened were to some extent a defence of oil. He had little sympathy with the prevailing view that all imports were bad and all exports good. There was

a balance of trade, but there was a balance of other things besides trade, a balance of common sense and utility. (Cheers.) There had been articles in the press, some of which had appeared very recently, upon the subject of coal and oil, to which he could not possibly subscribe. It was very necessary to maintain a sense of proportion. The total imports of petroleum in all its forms into this country were of the order of £25,000,000. The agricultural production of the soil of this country was of the order of £250,000,000; and, if agriculture enjoyed the assistance of a 250 per cent. *ad valorem* tariff, such as was enjoyed by the coal industry in producing petrol (laughter), he would guarantee we would not only restore our balance of trade, but wreck the damned thing. (Loud laughter.) It was very necessary to maintain a sense of proportion in these matters.

The constituency which it was his privilege to represent was partly industrial and partly agricultural; approximately two-thirds of his constituents earned their living in industries other than agriculture, and one-third in agriculture. During the last two months he had learned more, perhaps, than he had learned during the previous five or six years; he had been walking on foot from public-house to public-house (applause), from parsonage to labour exchange, from factory to workshop, from the pig factory to the pram factory, looking and listening, sometimes incognito, as his own natural self, and sometimes proclaiming himself to be his hearers' representative, whether they liked it or not, for the duration of the present Parliament. He had learned a great deal in that way of the intimate interdependence of every industry with every other industry. (Cheers.) Agriculture was, in the ultimate resort, the industry which carried all the others on its shoulders, and it was to agriculture above all that the present Government was turning its attention with a view to doing what it could.

He did not pretend it had done very much as yet. Milk was a sheltered product, to some extent, but farmers were getting less for it than last year. We had imported more meat in the first eight months of 1933 than at any previous time. It took more than two years to alter the great currents of trade, and it was going to take more than two years to alter a great many other things.

He would like to suggest to the members of the Institution, which alone of all institutions in Great Britain was fully representative of the petroleum industry, that they should pay attention to public presentation of the purely economic side of the industry. Their competitors in the coal trade were tireless in their presentation of statistics. The public knew precisely what they were doing—what wages they paid, what was the value of the coal exported,

the precise number of miners who had been thrown out of employment, and so on. One did not learn how many of those miners had always been miners; that was another story, which might well be investigated by a modern tabulating machine. (Laughter.) But when he turned, as an interested lay member of the public or as a Member of Parliament, to study the petroleum industry from the point of view of national economics, he was confronted with an almost complete lack of authoritative, objective figures. Those present that evening knew very well that if £25,000,000 worth of petrol and fuel oil and other mineral oils were imported into this country, we had on the other side of the sheet the value of the tankers made in this country which carried the oil, the value of the vast quantities of machinery and pipe-lines made in this country and sent abroad to the oilfields, the wages of the crews of the tankers, the home remittances of the British staffs employed on oilfields in foreign territories, and so on. They were painfully aware of the vast sums which were paid to the Chancellor of the Exchequer in respect of import duties and income and super tax. Even the average garage proprietor did not quite realise how much went into the Treasury. If those figures were to be presented for the industry as a whole, and an attempt made to draw up a credit and debit sheet, putting on the other side the dividends also which were distributed in this country by the oil industry, the balance-sheet which would result would be something very different indeed from that which was generally believed to exist. There was a tendency to put the gross figures on one side and ignore every other factor, and he submitted that it was worth while to endeavour to enlighten the public on the purely economic side of the matter. Vice-Admiral Brown had remarked, very truly, that the oil industry was open to conviction. It was open to conviction, but he thought it might very well be honourably acquitted (laughter), if only it would put forward its defence adequately, so that the public at large might realise what was at present realised only by a few.

He would like to make a very brief reference to the future. He was convinced that the doctrine of national self-sufficiency was in its essence a sound doctrine, and would make for peace. The more we could produce within our own borders of the absolute essentials of life the less we should fear others. Whether we liked it or not, however, the world had decided to follow the doctrine of national self-sufficiency to its logical end. Louis Napoleon, writing from his prison at Ham in 1841, said something like this: "March at the head of the ideas of your century. If you follow them, they will enslave you; if you oppose them, they will crush you; if you march at their head, they will sustain

you." We had no alternative but to adopt the policy which the world at large was adopting, and he believed we could succeed. (Applause.)

The economists, who as a body had been more consistently wrong even than the politicians (laughter), had perpetually tried to teach us every form of false doctrine, heresy and schism, and they were now very properly in disrepute. The instinct of the man in the street and the common sense of the business world was a far more powerful factor to-day than the theories of men who read voraciously what other men wrote and then proceeded to write a thesis to prove that they were wrong.

He believed we were on the threshold of a great renaissance of British trade and of British spirit. (Applause.) He did not want to weary his audience by lengthy quotations, although he had a fair stock of them, seeing that he had been electioneering fairly recently (laughter), but they might remember the classic speech of Emerson in the Hungry 'Forties at Manchester :—

> "I see England pressed upon by competing populations and trades. I see her not dispirited, not distressed, but remembering that she has seen dark days before and indeed with a kind of instinct that she can see a little clearer on a cloudy day and that amid the storm and stress of calamity she has a secret vigour and a pulse like cannon. I see her in her old age not feeble, not weak, but daring to believe in her powers of endurance and expansion, and with strength equal to the times."

No truer word could be spoken to us to-day ; we must dare to believe in our power of expansion. (Applause.) Those whom he was addressing, to whom no continent, and almost no country, was unfamiliar, who had spread their tentacles into every part of the world and who had brought science to bear upon their industry to an extent which, had it been applied twenty years earlier to coal, would have enabled us to tell a very different story, had every reason to share Emerson's confidence.

He would like to give one more quotation, from Macaulay, written in the *Edinburgh Review* for January, 1830, fifteen years after the Battle of Waterloo—and we to-day were fifteen years after the Armistice :—

> "The present moment is one of great distress. But how small will that distress appear when we think over the history of the last forty years ; a war, compared with which, all other wars sink into insignificance ; a taxation, such as the most heavily taxed people of former times could not have conceived ; a debt larger than all the public debts that ever existed in the world added together ; the food of the people studiously

rendered dear; the currency impudently debased and improvidently restored. Yet is the country poorer than it was forty years ago? We fully believe that, in spite of all the misgovernment of her rulers, she has been almost constantly becoming richer and richer. Now and then there has been a stoppage, now and then a short retrogression; but as to the general contingency there can be no doubt. A single breaker may recede, but the tide is evidently coming in.

"If we were to prophesy that in the year 1930 a population of fifty millions, better fed, clad, and lodged than the English of our time, will cover these islands—that Sussex or Huntingdonshire will be wealthier than the wealthiest parts of the West Riding of Yorkshire now are—that cultivation rich as that of a flower-garden will be carried up to the very tops of Ben Nevis and Helvellyn—that machines constructed on principles yet undiscovered will be in every house—that there will be no highways but railroads, no travelling but by steam—that our debt, vast as it seems to us, will appear to our great-grandchildren a trifling encumbrance, which might easily be paid off in a year or two—many people would think us insane. We prophesy nothing . . . We cannot absolutely prove that those are in error who tell us that society has reached the turning point—that we have seen our best days. But so said all who came before us—with just as much apparent reason."

There had always been prophets who said that the world was coming to an end and that England would prosper no more, but the good sense of the commercial world and of those who used their hands and their skill had brought us out of the mire again. He firmly believed that we were on the up-grade.

His wanderings on foot during the past two months on two or three days a week had revealed to him a degree of good will and unity in every class of the population which perhaps no other country in the world could show. It was his belief that England had socially never been in a better state than it was to-day. There was hope, there was confidence, there was self-respect, there was a willingness to sacrifice much for the next generation. If we kept a stout heart we might yet hearken to Milton's appeal to his countrymen in 1641: "Let not England forget her precedence of teaching the nations how to live." (Prolonged applause.)

The toast was drunk with musical honours.

Mr. T. Dewhurst, the President, in responding, thanked those present for their generous acceptance of the toast and Sir Arnold Wilson for his gratifying references to the Institution. In view of Sir Arnold's close association with the oil industry and with a

number of scientific societies and institutions they would be wise to attach considerable importance to his remarks. It was the custom at the annual dinner for the President not only to report on the health of the Institution, but also to present an X-ray photograph disclosing its internal structure and mechanism.

Mr. Dewhurst then referred to the constitution of the Institution as laid down in the memorandum and articles of association, by-laws and regulations, and stressed the fact that these documents embodied the lessons of great experience and that they should only be altered after close investigation in the spirit of Lord Falkland's dictum that "Unless a change is essential it is essential that there should be no change."

Dealing with the activities of Past-Presidents, he explained that there was a Past-Presidents' Committee, and that the chairman of some of their most important committees, such as the Publication, Standardization, House, Branch, World Petroleum Congress and Benevolent Fund Committees were all Past-Presidents, while only recently Mr. Adams was chairman of the Finance Committee.

He referred to the representation of the Institution on many outside bodies and to the many standing committees required to cope with the various activities of the Institution, and particularly to the Standardization Committee, which was in charge of Professor Brame. The Journal, which was now issued in twelve monthly parts, maintained its high standard and reputation. It was in the capable hands of Dr. A. E. Dunstan, their Honorary Editor, and of Mr. George Sell, their very hard-worked Associate Editor. The President was pleased to say that he received many tributes to the excellence of the results produced by the very hard-working Abstracts Sub-Committee. As time went on increasing use was made of the Library, while during the year Dr. Arthur Wade was appointed Honorary Librarian and Mr. George Sell Librarian. Those appointments had already been abundantly justified. The branches in Trinidad, Rumania, Persia and South Wales continued their good work, and with the object of developing the great potentialities of that section of their estate a branch committeee had recently been formed with Mr. Kewley as chairman.

The President then appealed on behalf of the Institution's Benevolent Fund, and expressed the pleasure of himself and his colleagues that Dr. A. E. Dunstan, the founder of the fund, had recently resumed the chairmanship of the Benevolent Fund Committee. Speaking of Mr. Arthur W. Eastlake's long service as Honorary Secretary, he stated that they all valued his wise council and continued to gather the fruits of his ripe experience. He then welcomed the new Secretary—Mr. Astbury—who entered on his duties only a few days ago. There was no change to report

in the membership. The numbers were practically the same as last year, which was not unsatisfactory in view of the general conditions which had prevailed in the meantime.

He proceeded to emphasise that a strong Students' Section was essential to the future of the industry, and of the Institution, and spoke highly of the quality of their student members. That year eight papers were submitted for the Students' Medal and Prize, and, following critical expert examination of those, the Awards Committee recommended to Council that the papers, "Railway Traction in Relation to the Oil Industry," by G. M. Barrett, and "Salt Domes," by R. V. Browne, be commended, and that the Medal and Prize be awarded to Mr. R. Chandler for his paper on "Heat Transfer for Fluids in Turbulent Flow in Pipes." The President then presented the Medal and Prize to Mr. Chandler.

The outstanding event of the year, he said, was the holding of the World Petroleum Congress. They much enjoyed meeting and exchanging views with so many foreign technologists, and much good, and nothing but good, would result from that association. He was excellently well placed to hear complaints and heard none, but, on the contrary, heard and saw many evidences of another kind, and from those emerged the plain truth that the Congress was a striking and even a complete success. The transactions would be published about the end of the year and would record such progress in each and every branch of petroleum technology that no petroleum technologist would be able to ignore them and keep up to date. The scheme of publication would soon be announced, and as the various publications would be limited in number, he recommended all interested to make early application for them.

The Institution had made enormous progress in its short life, and during the past year the rate of progress had even accelerated, but they had to be certain that the strength of the Institution did not lie in the inability of any one of the groups of specialists to criticise the other groups. He stressed the fact that whether they were engineers, chemists, geologists or physicists they had all had a scientific training and were imbued with the scientific spirit and familiar with scientific methods, and he believed that that broad common scientific foundation, and not their technological divergencies, constituted the basis of the unity which was their real strength.

The President then said that probably they had all tried to detect the main axis of the economic geo-syncline, and that in that connection the latest publication of the League of Nations stated that the nadir of the depression in the world's productive activity

appeared to have been passed about the middle of 1932. They, therefore, might hope that they had at long last entered the stage of slow revival, and that with an improvement in general conditions, there would be a corresponding growth in the size, prosperity and usefulness of the Institution.

In conclusion, Mr. Dewhurst referred to the retirement, less than a week ago, of Commander R. E. Stokes-Rees, R.N., and stressed the fact that the Commander, despite his youth, was retiring permanently. He held the office of Secretary for more than three-fifths of the entire life of the Institution, and saw the membership grow from about 460 to about 1300. Those facts spoke for themselves, and therefore he only needed to refer to the enormous value to the Institution of the very highly satisfactory personal contacts which the Commander had established with so many of their members who were stationed overseas. Commander Stokes-Rees had kindly presented to the Institution a gavel and block, which would be valued as a souvenir and welcomed as evidence that they would not be too quiet without him. A large number of their members had been delighted to subscribe to a testimonial to the Commander: that took the form of a handsome cheque, a silver cigarette box suitably inscribed, and an illuminated scroll containing the names of subscribers. The President then presented the testimonial to Commander Stokes-Rees, and on behalf of all subscribers, wished him long life, health and prosperity in his retirement. (Applause.)

Commander R. E. Stokes-Rees, R.N., who was welcomed with prolonged applause, said that he was hopelessly incapable of adequately expressing his gratitude, not only for the magnificent present given to him, but for the wonderful way in which the members had drunk his health, and also for the thousand and one kindnesses that they had shown him during the twelve years for which he had had the honour of being their Secretary. He knew that he had been likened to the "Mighty roaring bull of Bashan," and accused of keeping them awake at general meetings (laughter), but he only wished his voice was loud enough to be able not only to express his gratitude to his many friends present that night, but also to express it personally to those scattered over the four quarters of the earth. He would like to thank the President for the charming things he had said about him; if he never had any vanity before, he would spend the rest of his life strutting about like a peacock. (Laughter.)

It only remained for him to say "*Au revoir*," for he hoped to see them again when he came over. He would ask them to be as good to his successor, Mr. Astbury, as they had been to him,

and finally wished the Institution as a whole, and each and every member of it, not only here but all over the globe, the very best of health, long life and prosperity. (Applause.)

"Our Guests."

Mr. J. McConnell Sanders, who proposed the toast of "Our Guests," said that almost exactly a year ago the President alluded to the Fourteenth Annual Banquet as being unique owing to its international character. It was his privilege that evening to act as the mouthpiece of the members in welcoming their guests, and, though he could not make a similar allusion, he would remind them that barely two months ago they had the opportunity of demonstrating their capacity for acquiring, promoting and consolidating international relationships in a very special manner.

On the present occasion they met together in a more intimate sense. Having sallied forth to leave their footprints on the sands of international endeavour, they returned well satisfied to their own surroundings and to their own friends, who understood and appreciated them as they themselves were understood and appreciated. Those footprints might be washed out by subsequent tides of controversy or misunderstanding, or might be filled up by the wind-blown Tufa from extraneous eruptions, but here their feet were on solid rock and the impressions they left were calculated to withstand the ravages of time, and, they hoped, might be dug out of their records by technologists in the future and admired for their excellent state of preservation.

It had always been a matter of surprise to him that civilised mankind had never succeeded in producing a more original method of promoting friendliness than by inviting a guest to share a modicum of internal combustible in the shape of food and/or drink. (Laughter.) That surprise had been intensified by the recent pronouncements, which no doubt the members had seen in the Press, of Dr. F. C. Dodds, who said that a dozen oysters yielded only 88 calories, as against 100 for a piece of brown bread and butter. That was not altogether, however, a matter for surprise, for personally he had never regarded an oyster as a very energetic animal. (Laughter.) It was more difficult to digest what Dr. Dodds said about bread and butter. Further, it was said that if one made beef-tea by the usual procedure and gave the tea to an invalid and the residue to a dog, it was the dog which got the calories. Obviously the remedy was to start from the other end and boil the dog, so as to utilise its residual affinity (laughter), but that was a process confined to a highly specialised branch of the culinary trade, originating, he believed, in our oldest University towns. (Laughter.) Speaking of culinary matters reminded him that no one

had ever settled whether cookery was a science or an art, although in one sense this should not be difficult to decide, for if one took the "g" out of gastronomy the answer was obvious.

That suggested a somewhat fascinating idea. When the President honoured him by asking him to propose the health of the guests, he naturally looked through the fourteen speeches delivered by the other proposers of the toast on previous occasions, and realised it would be difficult to find something which had not been said before. In order to try to be original, he would suggest that his audience should consider themselves and the rest of mankind as heavenly bodies—using the term, of course, in its metaphorical sense—and as moving through space in orbits which might be circular or elliptical, sometimes concentric with other orbits and sometimes, if he might dare to suggest it, eccentric. Some of them were wanderers, travelling into distant spaces to return anon with brilliantly scintillating trails—he said *trails* (laughter)—of acquired knowledge or splendid achievement. Some, again, plunged in meteoric fashion into the atmosphere, encountering so much friction that they blazed out awhile in auto-combustion and then joined the breezes which fanned our faces.

To carry the analogy nearer home, they might imagine themselves that evening gazing into the starlit vault and noting the stately transit of other planets across their field of view. If one examined those planets with the spectroscope of friendly inquiry, one found them easily distinguished by bright lines of great achievements, and often it was gratifying to find that some of the lines on their spectra coincided with those of the members.

The spectroscopic allusion was, he thought, justified, for he noted amongst the distinguished guests that evening a planet of the first magnitude, Sir Robert Robertson (applause), who among his other activities had contributed to their knowledge of absorption spectra in the infra-red. If Sir Robert had been as ardent a politician as he was a brilliant scientist, he could perhaps have shed enlightenment regarding the best method of absorbing the "ultra-red" (laughter), and, had he been an Irishman instead of a canny Scotsman, he might have done something about the ultra-blue or violet which seemed to be the coming fashionable colour among shirtmakers in the Distressful Isle. (Laughter.)

Another luminary which appeared on the horizon and whom the members were delighted to see was Vice-Admiral Sir Percy Douglas. (Applause.) Again he found his allegory justified, for Sir Percy was a member of the Royal Astronomical Society and therefore must often have sought inspiration from the stars in the course of his strenuous activities as hydrographer to the Royal Navy. He noted that his spectrum showed several bright

lines not altogether unconnected with sextants and other instruments for the pursuit of heavenly bodies.

The Premier Service was also represented by another star of the first magnitude in the person of Engineer Vice-Admiral Brown (applause), who, as engineer-in-chief, must frequently have thanked his lucky stars that petroleum fuel had been made available by the efforts of petroleum technologists. The members were delighted to have him among them and to number him as one of their lucky stars.

There was no need to point his allusion to heavenly bodies when referring to the Royal Air Force, whose well-known motto was indicative of their high ideals and practice. The members extended the heartiest of welcomes to Air Vice-Marshal Sir Hugh Dowding (applause), in whose spectrum they noted some strongly-marked lines indicative of a subject dear to their heart, research. Another distinguished and welcome guest was Major-General Evan Gibbs, Director of Supplies and Transport to the War Office. His orbit must frequently have run concentrically with that of the members, for many of his problems had given them furiously to think. Still more closely associated with their own system was Engineer-Captain S. H. Dunlop, whom all the members welcomed. His spectrum served as a standard of reference, for he held a watching brief for the Admiralty on the Standardization Committee of the Institution, and saw to it that certain of their spectral lines coincided with his.

One way of seeing stars, or indeed of reaching them, was by the use or misuse of explosives (laughter), and there he trod on dangerous ground, for he noted that Dr. H. E. Watts, from the Home Office, was present, and what Dr. Watts did not know about explosives must be smaller than cosmic dust. He could assure Dr. Watts, in case he harboured suspicion of some petroleum products, that they never exploded of their own volition, their infrequent misbehaviour being always due to the malign influence of some other star; if they detonated, it was because someone had omitted the symbol for the planet Uranus from the mystic formula H.U.C.R., leaving only the H and the C. (Laughter.)

It needed no special words of his to indicate the bright lines in the spectrum of another planet whose influence had always been astrologically benign. He alluded to Mr. F. C. Starling, head of the Petroleum Department at the Board of Trade. (Applause.) His orbit often crossed that of the members, and they always benefited by the collision, or perhaps he should say collusion.

Still another planet had appeared among the Novæ, a guest for the first time, but not, it was to be hoped, for the last time,

Dr. J. T. Dunn, the distinguished President of the Society of Chemical Industry. (Applause.) If Dr. Dunn had escaped their spectroscope heretofore, it was simply because his light had been burning brightly elsewhere. The members welcomed him very heartily. It was also a great pleasure to them to have Sir Ernest Pascoe with them that night. His activities and valuable contributions to geological science were well known to them and highly appreciated. (Applause.) They hoped his friendship for them would be like a mineral found in the country in which he had worked so long—laterite, which had the remarkable property of hardening on exposure and, if broken, automatically cemented itself together again. That was the true kind of friendship. When one thought of India or of Persia one turned instinctively to a very welcome visitor whose light had already illuminated the members to a marvellous extent. There was no need to reiterate their cordial thanks and good wishes to Colonel Sir Arnold Wilson. (Applause.) They knew him to be an able exponent of the beauties of Persian art, and they now knew that he could speak in moving terms of politics and petroleum technology and of the two combined.

So far he had confined his star-gazing to those heavenly bodies whose visits to the system represented by the members had been chiefly periodic; but there were also the fixed stars, those luminaries which hung suspended above them, wreathed in splendid constellations, always shedding beneficent beams upon their activities and often profoundly influencing their destinies. Chief among them could be distinguished the great Oil Companies, with their attendant satellites and occasionally with their rings. (Laughter.) Although they numbered more than twelve, some of them at least could be classified in zodiacal manner. One thought of Gemini, the Heavenly Twins—Shell-Mex and B.P. (Laughter.) No one could represent them more adequately than Mr. J. B. Aug. Kessler, whom the members welcomed very cordially. (Applause.) He might be sure the Institution would never say of him, "This is a friend, that was." (Laughter.) Again, Sirius, the Dog Star, was symbolised by Lobitos, the place where the bark came from. If Mr. Arthur Beazely were present he might say that quinine had nothing to do with oil, but there were many oilfields from which little oil would come if they were not freely supplied with that useful drug. Then there was Boötes, the ploughman, excavating in Iraq, while his dog barked sullenly at Ursa, the Russian bear, and Polaris meant Apex, represented by Mr. W. Maclachlan, whose welcome among the members was assured beforehand. In Mr. H. B. Heath Eves they had a very welcome visitor who represented a mighty constellation symbolised by Orion, the warrior, with his girdle of stars. In Greek mythology it was said that when

Orion rose at midnight it heralded the season of vintage, but the members would drink his health before that time and ask him not to rise while they did it. (Laughter.) Taurus was not numbered among their constellations, although Throgmorton Street would probably supply him, and also Ursa, when required. (Laughter.) Sir Basil Kemball-Cook, who was very welcome, probably belonged to Aquarius, but, in view of his confession earlier that evening, it was doubtful if he could prove it by spectroscopic analysis. (Laughter.) Mr. T. Outen, who shined in the constellation Libra, often shed legal light on the deliberations of the Institution. Auriga, the Charioteer, was symbolical of the great distributing companies represented that evening, and which, as always, were very welcome.

There were many other friendly constellations represented, and he must not forget the Press, whose friendly beams were always illuminating the darkness. Theirs was a light which it was difficult to analyse spectroscopically, for it was a continuous spectrum and many-hued, though occasionally shaded with absorption bands. (Laughter.) The members were also pleased to welcome Mr. Fred May, whose clever pencil sometimes depicted them in a manner suggestive of that group of stars which constituted the sign of Capricorn.

In conclusion, he would like to address a special word of welcome to a luminary who combined the attributes of both planet and fixed star. Mr. Herbert Williams was both a Member of Parliament and a distinguished engineer. If in the former capacity his orbit led him among the greater nebulæ, in the latter the members knew by his writings that he was fully able to clear the air and give them a clearer vision of things economically political or politically economical.

The time had come for him to follow his fanciful allusions to their logical conclusion and to subside in eclipse, but before doing so he would ask the members to charge their glasses—not, he suggested, in a milky way—(laughter)—and to drink to the toast of the Guests, coupled with the name of Mr. Herbert Williams.

Mr. Herbert G. Williams, M.P., in reply, said that for a few moments he would like to follow the lead given by Sir Arnold Wilson, who had struck a serious note and who had impressed him very much by what he had said. The nation was faced with a very difficult problem in the conflict between different sources of energy. In 1913 we both sold and bought fuel; we sold coal and we bought petroleum and its products.

The net result was that our balance of trade was £40,000,000 in our favour so far as our trade transactions in fuel were concerned. That enabled us to buy all sorts of things. In the first half of the

present year we paid more for fuel than we obtained by selling fuel. That represented a real economic revolution, and was a very serious matter. The petroleum industry had done it, but they had to think out the consequences of what they had done. After all, this country had to buy from abroad.

Personally, he was a narrow-minded economic nationalist, for reasons which were not often stated. He thought it was a tragedy that if a lot of stupid people played the fool in Wall Street in 1929 they should be able to wreck the world by their folly. (Applause.) It was ridiculous that the folly of one country should be able to wreck every other country. It was what happened in the United States which drove us to disaster. All kinds of fancy explanations had been given for the troubles from which the world was suffering, but if one examined the dates one found that the collapse on Wall Street was the real cause, despite the fact that a thousand and one other explanations were offered. So long as a country was economically self-sufficing it did not suffer from other people's folly, and Heaven knew that in this country we suffered enough from our own. (Laughter.)

We had very much exaggerated the importance of our transactions with foreign countries. At the present moment not more than 6 per cent. of our people were engaged in making goods which were bought by foreigners. That was a startling fact, and when he stated it in the House of Commons six months ago, nobody would believe him, but it was roughly true. One could very much exaggerate, therefore, the importance of our export trade, and from one point of view it might well be asked why we should export anything except in so far as it was necessary to pay for imports. There was no intrinsic merit in export trade; it was only a device by which one got things from abroad. It meant robbing oneself of the fruits of one's labour in order that other people might consume them.

He held violent views on the subject, and thought the United States at the present time was an economic lunatic asylum, for the view was held there that the more inefficient you were the more prosperous you would be, and the less goods you had the better off you would be; the less people produced the better for the world. He thought that in that direction supreme lunacy lay. The members could thank God that they were technologists and not economists, and that they spent their time trying to find out how to do things better than before. He wished them God speed in their work, because the standard of living of the people of this and every other country could be raised only by increasing the efficiency of production. The world was not short of goods, but he would like to ask them to write down the things which

they would like to buy if they had the wherewithal to buy them, and to remember that they could obtain the wherewithal in the long run only by rendering services and producing goods. They should set their faces against the unadulterated nonsense which was talked at the present time by nine-tenths of the alleged statesmen of most of the countries of the world. He denied that there was anything in the doctrine of inefficiency.

The fear of competition from coal remained. Sir Arnold Wilson had referred to 250 per cent. *ad valorem* protection, but only half that had been guaranteed. He had supported the proposal in the House of Commons, because he thought we ought not to be entirely dependent for liquid fuel on imports from abroad. He did not believe that at any time in the future which could be foreseen the production of oil fuel from coal would be absolutely economic, but one never knew what might happen, and we were entitled to protect ourselves so that if at any moment we were isolated we would still have some resources of our own. On grounds of national security there was something to be said for the idea.

He attended a great many functions every year of a national and local character, and knew there were numbers of teetotallers about, but whenever really distinguished people were present he found they all drank, and he followed their example. (Laughter.) Those connected with the petroleum industry, however, should realise that they were now producing more for the national revenue than spirits were doing, and were only beaten by beer and tobacco. They occupied a position of pride ; the Chancellor of the Exchequer loved them.

On behalf of all the very distinguished guests, and on his own behalf, he would like to thank the Institution for its most generous hospitality, but he did wish they would persuade their allies and colleagues, those who made internal combustion engines and motor cars and those who used them, not to kill so many people. It amazed him that every year more people were killed by vehicles using petrol than had been killed each year in a great enterprise like the Boer War. One of the outstanding causes of death to-day was the motor car, and he was amazed at the way that fact was accepted. Most of those deaths were due to insufficient care being taken, but public indignation did not seem to be aroused by the fact that it was more dangerous to walk in the streets to-day than to fly in an aeroplane or to work in a coal mine, taking hours of exposed risk. It was tolerated, however, although the motor car was to-day amongst the first twelve of the causes of death according to the classification of the Registrar-General. Those connected with the petroleum industry provided the fuel for the

vehicles, and he thought they ought to play their part in helping to prevent accidents. We had to-day our Factory Acts and regulations in regard to all industrial diseases and accidents, yet industrial accidents did not kill as many people as motor vehicles. He thought the position was appalling.

In conclusion, he would like to thank the members for their delightful and charming hospitality, and to wish them well in all their enterprises.

The proceedings then terminated.

REVIEWS.

PETROLEUM DEVELOPMENT AND TECHNOLOGY, 1933. New York: American Institute of Mining and Metallurgical Engineers, 1933. Pp. 426. $5.

This compilation is the annual selection of papers from the Petroleum Division of the Transactions of the American Institute of Mining and Metallurgical Engineers, and as in previous years it contains articles by recognised authorities on subjects of immediate importance. Some 68 papers are divided into five subjects in an equal number of chapters.

Under the heading of "Stabilization" 13 contributions are included where the vexed subject of Rationalization is approached from many standpoints by economists, lawyers and technologists. The subject is introduced by Earl Oliver with a sermon on the past iniquities of oil men encouraged, if not occasioned, by antediluvian laws and customs based upon capture of oil by the smartest. Waste is attributed to speculative frenzy due to uncontrolled development of new oil pools, which results in demoralization of business and labour, fraudulent stock transactions, graft in politics and disregard of the elementary laws of economics. He pleads for a change of attitude from being highly competitive, which he maintains is merely another term for selfishness, to that of co-operation. The writer, it is pleasing to note, pays a well-earned, if belated, tribute to Mr. Doherty, who alone of the prominent leaders of the oil industry had the courage to fight for principles which have since received the official blessing of the American Petroleum Institute by resolution, which is too well known to repeat. A useful bibliography of 121 papers dealing with the subject follows the paper.

The debate on Umpleby's paper, "Reservoir Energy," is especially illuminating in demonstrating the impossibilty of distinguishing between energy and gas; the former being "an invisible, intangible force or power present in the formation which confines the oil and its accompanying gas." Several speakers in the debate which followed referred to the difficulty of assigning values to the owners of land covering gas caps if the exploitation of gas is disallowed; and if a value is attached to gas, have not owners of land underlain by edge water an equal claim for compensation if they do not dissipate that energy by its release; also what proportion of energy, if any, is due to weight of overburden?

To Economics is devoted five articles with an introduction by H. J. Struth, who stresses the far-reaching influence exerted by East Texas on the crude and gasoline market. He reveals by figures an improvement in U.S.A. conditions over 1931 with well completions increasing from 12,000 to 14,500 against a peak of 34,000 in 1920, and a crude oil value of $607,000,000 compared with $493,000,000 in 1931. The automobile situation discussed in relationship to the demand for gasoline and crude oil is dealt with by S. A. Swensrud. He estimates that 1,300,000 new vehicles were added and 3,250,000 were scrapped in 1932, leaving at end of the year 21,200,000 available for use. The life of the average car has been estimated at 7.04 years. When discussing the price factor the author refers to the narrowing margins between the cost of gasoline and its retail price, using for his calculations the retail prices in 50 U.S.A. cities, and the estimated cost of manufacturing gasoline in Mid-Continental refineries. These differences were in 1929 11·2c, 1930 10·3c, 1931 9·2c, 1932 8·5c per gallon, but much gasoline was sold below the posted price.

In a second paper Mr. Struth deals with the economic influences of the gasoline situation.

"A Comparison of Old and New Oil Fields" is the title of a paper by L. C. Snider who, with the aid of many production records, shows the

diminishing influence of new oilfield discoveries on the industry. He submits that if his evidence is dependable the present situation as regards over-supply of crude is no worse than it has been many times in the past, and he attributes the prevailing alarm and pessimism to various causes, including failure to distinguish between potential and critical production, over-estimation in the flush stage, rapid development of deep fields and inadequately appreciating the increasing difficulty in finding new production in old fields.

Production Engineering is briefly introduced by E. A. Stephenson in chapter III., who outlines the major developments of the year. Incidentally he remarks that the use of flush-jointed casing and drill pipe have reduced drilling time from by 5 to 20 per cent. H. C. Fowler summarises in a few lines the directions in which engineering research has been usefully pursued.

A fascinating and almost thrilling account is given by Mr. Roy Silent and N. A. Rousselot of the killing and reconditioning of two pioneer wells on the North Kettleman Dome, California. No drilling engineer should fail to read this article descriptive of great difficulties successfully overcome by experienced field engineers through the exercise of high skill, infinite patience and care and masterful resource.

Some notes on the "Effects of Temperature on the Viscosity of Gulf Coast Drilling Muds" are made the subject of a short paper by Mr. B. C. Craft and J. D. Exner, and it is shown that varying effects are produced on muds of different composition.

Mr. Clifford S. Wilson's paper, entitled "Selection and Use of Screened Pipe," is a valuable contribution to the subject of screening. The destructive and harmful influence of sand on oilwell fittings is generally recognised, and where controlled flow fails to stop its admission to wells, the use of a screen designed to support the walls of a bore whilst permitting the entry of oil in economic quantities is an important question. The principles of screening are clearly described, and the conditions which lead to abrasion are considered. It is claimed that by using slots of proper dimensions to suit the sands effective natural filters can be formed which will restrain the admission of sand without imposing a serious resistance to the inflow of oil. A number of screen analyses of sands made demonstrated that with few exceptions most of the grains are of closely uniform size, the greater part of the gradation taking place at the extremes of the grain-size range. The article concludes with a method of mathematically computing the mesh required to deal with sands of varying kinds.

Some interesting notes showing the relationship of diameter of core to percentage recovery are given in a paper in abstract by R. W. Brauchli. It was found that 1¾ in. cores led to a recovery of 29·1 per cent. and the percentage increased progressively to 68·5 per cent. with a 3¼ in. core taken on 6¾ in. drill pipe; but it was also ascertained that the core recovery increased with a larger and more rigid drill pipe.

Bottom hole pressures form the basis of two papers. C. V. Millikan discusses "Reservoir and Bottom-hole Producing Pressures as a Basis for Proration," and D. G. Hawthorn writes on "Sub-surface Pressures in Oil Wells and their Field of Application." The first author emphasises the danger of fixing potentials by individual flows as capacity may be far higher than is permitted by the size of flow pipe or than it is expedient to flow owing to the risk of sand influx or water intrusion. Maintenance of uniform reservoir pressures at all stages of depletion is regarded as the most equitable way of prorating oil production. This method ensures that there will be no travel of oil and gas from the drainage area of one well to that of another whilst preserving for the leaseholder the advantages of permeability, thickness or other factors which give to one area a greater value than another. He,

however, does not fail to direct attention to the practical difficulties in reaching an equitable distribution in many cases and draws attention to the peculiar problems which arise when a natural water flood is in progress.

An article by D. A. Hawthorn, entitled "Sub-surface Pressures in Oil Wells and their Field of Application," is a timely attempt to place a rational interpretation on obscure data, although it starts with the erroneous statement that the earliest sub-surface tests were made in Rumania with a pressure bailer in 1918 and 1919. Experiments, as a matter of fact, were undertaken as early as 1902 in the Russian oilfields where the duplex or pressure bailer to which reference is made was used for drawing fluid from the base of wells with excessive gas interference. The author refers to the confusion of ideas which surrounds the subject, but admits that the interpretation and application of collected data is far from a simple matter. He defines common expressions used, and employs the term "Productivity Factor" to represent the rate of production divided by the differential pressure.

"Permeability Factor" is described as "Productivity Factor," divided by sand penetration and a factor K dependent upon the diameter of hole. The application of bottom-hole pressure methods to estimations of ultimate recovery in such fields as East Texas, where all gas is in solution, is described as unreasonable, and unsound where a water drive is in progress. Engineers would regard as "Utopia" a rate of production which kept exact pace with water encroachment and the sustenance of a constant reservoir pressure.

A recorded discovery which seems to have occasioned some surprise was the ascertained accumulation of water in wells which continued to flow clean oil, a phenomenon which was known in Russia and Rumania 30 years ago. The influence of bottom-hole chokes on pressures in the flow column is graphically represented, but the anticipated troubles through paraffin wax precipitation in East Texas wells never materialised on account of the quick recovery of earth temperatures after expansion.

An instructive paper, entitled "Calculation of Pressure Drops in Flowing Wells," is followed by an equally instructive discussion in which common-sense views are expressed. The conclusions reached are that pressure drops in flowing wells can be calculated with reasonable accuracy except in the case of low pressure wells, also that properly dimensioned straight tubing is as effective as tapered, and further that gas-oil ratios cannot be controlled by design of tubing, except as regards depth with relation to sand.

Water-drive problems are the main theme of two long papers by K. B. Nowels and Messrs. Wyckoff, Botset and Muskat, and both will repay careful reading by those interested in water floods. The small recoveries of oil obtained by employing natural flood are attributed to the low pressure of the input water. Sand cores in the Bradford field show saturation equivalents of between 10,000 and 40,000 brls. per acre, whereas actual recoveries have varied between 2000 and 8000 brls. per acre. Ground can be covered from an economic standpoint on the five-spot arrangement of spacing by using a pressure on the face of the sand equal to 1·6 times the resistance between wells. The second paper deals with some novel experiments conducted to ascertain the flood patterns assumed by water under various conditions simulating those of an oil sand with an orthodox arrangement of wells. Changes of flood course due to obstructions are studied and illustrated.

Under the title of "Some Studies on the Porosity and Permeability of Rocks," a paper is presented by Prof. F. G. Tickell and two collaborators at Stanford University. These authors discuss methods of determining the permeability of rocks. They arrive at the conclusion that the porosity of

a rock is governed by : (*a*) the grain-size distribution ; (2) the angularity of grain ; (3) the degree of compaction, and (4) the colloidal content. The term " perm " is suggested to designate the unit of absolute permeability.

In another paper the " Development of Hydrogen Porosimeter " is described by Messrs. Coberly and Stevens of California.

Chapter IV., headed " Production," contains a series of 31 papers, one of which by H. J. Wasson introduces the subject of production in 1932. Thirteen articles deal with U.S.A. oilfields and seventeen discuss foreign oilfields. Of the world's production of 1,300,000,000 brls. in 1932 the U.S.A. produced 60·7 per cent. In the Eastern fields of U.S.A. activity was mainly confined to the water flood regions in the Bradford and Allegany fields. The reduced demand for gas in all fields due to general industrial stagnation was a factor which operated adversely in most fields. In the discussion of the Eastern fields it was revealed that a well was successfully drilled to 9104 ft. with cable tools when very heavy strings of casing were landed. Another important disclosure was the proof that commercial gas fields had been located where the carbon-ratio exceeded 65 per cent., the limit placed by David White's carbon-ratio theory of oil and gas occurrence.

The interesting statement is made when describing developments in North Louisiana that acid treatment of wells in the Zwolle and Converse fields had proved highly successful. The first well so treated had its production raised from 8 brls. a day on the beam to 600 brls. by flowing. Oklahoma developments in 1932 are described as colourless, but the discovery of heavy 22° A.P.I. gravity oil in the " Wilcox " sand in Lincoln county caused surprise, as Wilcox oil is nearly always light in density. When dealing with Kansas, Koester remarks that no oilfield of consequence in Western Kansas has been discovered without the benefit of geology or geophysics since 1924.

Almost with trepidation the article on the East Texas fields is sought as it accounted for practically 60 per cent. of the U.S.A. drilling in 1932. The author of this contribution, Harold Vance, considers that the 6000 wells drilled during 1932 had an average initial capacity of 2500 brls. At the close of the year there were approximately 9500 completed wells, and the field had produced about 245,000,000 brls. of oil. The original average pressure is given as 1630 brls., and there has been a drop in bottom hole pressure of about 1 lb. per 1,000,000 brls. of oil produced. During the period of unrestricted production in the summer of 1931 the pressure contour lines were badly distorted by unequal withdrawals, but during the period of military occupation and shut down in August, 1931, pressures readjusted themselves, and during the subsequent 15 months of restriction the pressure-contour lines returned to their original position. An estimated recovery of 2,000,000,000 brls. from 100,000 acres is predicted, although it is calculated that 75,000,000,000 cub. ft. of gas have been produced, of which only 10 per cent. was utilised.

In the paper on West Texas and New Mexico the writer mentions that striking results have followed the use of bottom hole electric pumps in two fields where wells yield over 2000 brls. a day of fluid, oil outputs being raised from 10 to 20 brls. to 250 brls. of oil daily in the case of the one pool.

Although the Texas Panhandle gas and oilfields were under restriction some 776,000,000 cub. ft. of gas daily was processed with a yield of some 5,350,000 brls. of gasoline and 88,000 tons of carbon black, but nevertheless about 223,000,000 cub. ft. of dry gas were daily discharged into the atmosphere compared with 41,000,000 cub. ft. used for domestic and industrial purposes. Acid treatment of lime wells has been attended with some encouraging results.

Gulf Coast developments are skilfully handled by L. P. Teas, who refers to the notable discoveries of deep-seated domes with continuous " blanketing "

sands in place of the treacherous flanking sands. By far the most valuable strike is the Conroe field, 30 miles N. of Houston, where thick rich sands appear likely to cover 15,000 acres. As the combined production acreage of all Gulf Coast Domes is only about 23,000 acres, the depth of the sands 5000 ft. and the gravity of the oil 38° Bé., the importance of Conroe will be at once appreciated.

Discussing the Californian situation, the contributors to this section describe the efforts made to restrain production to market needs in order to sustain prices. More favourable allotments were made to those working plots subject to drainage then to those with firmly held acreage, and although quotas were not closely observed by all operators production was 10,700,000 brls. lower than in 1931, and stocks of oil products fell nearly 1,600,000 brls. The proven oil reserves of California are estimated to be 3,965,000,000 brls., of which total Kettleman Hills North Dome is credited with about half. Gas production amounted to 277,000,000,000 cub. ft., of which only 17,500,000,000 cub. ft. of dry gas was wasted; the daily waste of gas falling from 84,000,000 cub. ft. in April to 16,800,000 in December. No new fields were discovered, but the striking of 2000 brls. of 50·4° oil in the North Belridge field at 8062 ft. in a hitherto unknown horizon opens up vast possibilities for deep oil in many fields. A pressure in excess of 3200 lb. was registered in the casing during the process of killing the above-named well, due to the high gas-oil ratio of about 40,000 cub. ft. per brl., and this pressure constitutes a record for California. The deepest producing well in the world was completed in the Ventura Avenue field at 9710 ft., where it flowed 5547 brls. per day of 30·1° gravity oil with only 4,568,000 cub. ft. of gas.

Garfias introduces the papers dealing with foreign oilfields by an estimation of the world's proven oil reserves. Those of the U.S.A. are estimated at 12,000,000,000 brls. or 48 per cent. of the world's total of 24,465,000,000 brls. Russia is given second place with 3,000,000,000 brls. and Irak, Persia and Venezuela closely follow. The outstanding feature of Canadian developments was the drilling of a well in the Turner Valley field to 7555 ft., which passed out of the Madison limestone at 5560 ft. and encountered some showing of oil in the underlying formations of probable Devonian age. Recoverable gas reserves of the same field are estimated at 600,000,000,000 cub. ft.

Venezuela presented no surprises in 1932, but of interest are the statements that gas-lift was widely and successfully practised using high pressure formation gas, and that repressuring experiments were under way in the Mene Grande field. The U.S.A. tariff of 21c. per brl. on imported crude and fuel oil and 2½c. per gallon on gasoline and kerosine is expected to influence markets. Progress in Argentina advanced substantially as, besides an increase of production to 13,000,000 brls., interesting developments occurred in Mendoza, Salta and Plaza Huincul. Much confusion and hindrance to progress have been caused by political and legal squabbles.

Curtailment of production is responsible for the large reduction of output from Peru, which shows a fall from 12,400,000 brls. in 1930 to 9,900,000 in 1932. The Negritos proved area now approximates 13,500 acres.

Russian events are hastily reviewed in a paper of five pages, wherein the author takes care to emphasize the many advantages the oil industry secures through operating under Government ownership without restrictions on rich lands, many of which were confiscated with their full equipment. The plan to produce 484,000,000 brls. in 1937 is a big leap from 150,000,000 brls. in 1932, and its fulfilment will involve the active exploitation of many new fields to replace the diminishing yield of the old major fields of the Caucasus.

Due to the restricted internal consumption, exports of Russian oil were estimated at over 40,000,000 brls.

Brief articles on Colombia and Rumania reveal little of especial interest as curtailment was practised in both countries. German operations are carefully summarised and analysed in an article of six pages. A fair amount of prospect drilling on salt domes has resulted in no discovery of importance, and to the failure of the Volkenroda field, which seemed to offer so much promise, is ascribed the very small increase of production in 1932.

The production of France, Italy and Poland are summarised in a short paper. No noteworthy developments took place, although in Italy 97,000 ft. of drilling was accomplished. Poland registered a fall in output of 14 per cent. in 1932.

In an informative review of Persian Development, Sir John Cadman states that the Haft Kel field has now been proved over an area of 40 sq. miles, and that it is likely to equal in size and importance that of Masjid-i-Sulaiman. In the oil field initial productions average 20,000 brls. a day against 600 lb. per sq. inch back pressure; gas-oil ratios are around 480 cub. ft. per brl. The pressure in the gas dome has only dropped 5 lb., although over 140,000,000 brls. have been abstracted. Reference is made to scientific work in progress aimed at conservation of reservoir pressure and rational exploitation. Irak operations receive notice in a brief article.

A good account of the Burman and Indian oilfields by Dudley Stamp concludes with the remark that there is very little possibility of discovering new fields unless some of the known structures in Baluchistan exceed expectations.

Two further papers entitled "Petroleum Development in Africa" and "Petroleum Production in the Dutch East Indies and Western Borneo (Sarawak and Brunei) during 1932" conclude the review of the world's operations. Concerning the first paper, it is observed that no oilfield of importance has been located outside Egypt. As regards the second paper, it is shown that out of a total of 42,400,000 brls. South Sumatra yielded nearly 14,000,000 brls. and the Island of Tarakan 6,600,000 brls.

Chapter V. is devoted to a brief review of Refinery Development by Walter Miller who refers to the continued movement towards higher anti-knock values for gasoline.

Attention is called to the recent erection of a combined skimming and cracking unit at the Whiting refinery of the Standard Oil of Indiana which will process 20,000 brls. of average Mid-Continental crude a day, producing 70 per cent. of 70 octane gasoline.

Reference is made to the practice of "reforming" low grade gasoline into a higher anti-knock product, to semi-vapour phase cracking, and to gum inhibitors. Mention is also made of the surprising yet popular practice of blending lubricating oil with gasoline, the benefits of which are far from certain. The writer refers to the development of a method of making bituminous paving mixtures as a by-product of cracking crude residues, also to the progress of hydrogenation as applied to lubricants and the improvement of lubricating oil fractions by solvent extraction.

Great credit is due to the compilers of this volume, without which the library of no petroleum technologist could be considered complete. The mass of selected data condensed into convenient space gives to the contents a special usefulness to those who have not the leisure to seek information distributed in many sources.

A. BEEBY THOMPSON.

CHEMICAL REFINING OF PETROLEUM: THE ACTION OF VARIOUS REFINING AGENTS AND CHEMICALS ON PETROLEUM AND ITS PRODUCTS. By Vladimir A. Kalichevsky and Bert Allen Stagner, Ph.D. Chemical Catalog Co., New York, 1933. Pp. 451. $7.00.

Chemical Refining of Petroleum is one of the Monograph series of the American Chemical Society and describes refining by the use of sulphuric acid, alkaline reagents and various sweetening agents, refining by absorption, and also the use of solvents in refining. Amongst other subjects discussed are the reduction of total sulphur in light petroleum distillates, detonation and anti-detonants, oxidation and reduction of reaction, gums in cracked petroleum products, and the deterioration of lubricating and similar oils. Numerous references are given, mainly to the more recent literature.

The authors also give a supplementary list of patents on petroleum refining, dating from 1853, grouped under the various chapter headings and also a glossary of terms.

The introductory chapter deals with the properties of various types of hydrocarbons, and the data are given for the physical constants quoted from other publications. The specific gravities of the individual hydrocarbons are given at a series of different temperatures, and the value of the tables is therefore less than would be the case were these corrected to the temperature of 60° F. Furthermore, the figures quoted are in some cases not in accordance with those obtained in recent work.

The various factors involved in refining with sulphuric acid are described in some detail under the usual headings, and an especially valuable section is that concerning the effect of temperature on the treatment.

The following chapter deals with sulphuric acid sludge from petroleum, and describes various methods of disposing of the acid sludge, together with methods adopted for the separation of the sludge into acid and oil; the concentration of acid separated from sludge is next described and includes a brief description of the Hechenbleickner Sludge-Contact Process which has recently been developed, in which the undiluted acid sludge is converted into porous coke and sulphur dioxide. A full account of the recent work on the mechanism of the sweetening process by means of sodium plumbite solution is given, together with a description of the preparation of the commercial reagent, of the sodium plumbite treatment in the refinery, and of the regeneration of the exhausted sodium plumbite solution. The use of hypochlorite solutions in sweetening operations is also fully described.

Under refining by adsorption, a description of the use of bleaching earths for lubricating oils, both by percolation and contact filtration, is given; in this chapter, also, a description is given of the use of these reagents in the refining of cracked gasoline.

The chapter on the use of solvents in refining is mainly concerned with the Edeleanu process, and the separation of paraffin wax by solvents, and the more recent development of solvent extraction processes such as those employing phenol, nitrobenzene and dichloroethylether, if included, are only briefly described.

In the chapter on the deterioration of lubricating oils, reference is made to a number of laboratory tests which have been put forward for gumming of sludging tendencies, but no distinction is made between tests of importance from the point of view of the refiner, and tests of no significant importance. Thus the British Standard Test for "Tendency to Sludge" of transformer oils is given under two headings with two separate references under the name of "Michie Test" and "Sludge Value," the correct reference being given in the case of the latter reference; further, the British Air Ministry oxidation test is quoted from a reference in the literature instead of being

referred to Air Ministry General Specification DTD109 for Mineral Lubricating Oils.

A number of miscellaneous refining processes are also described, and the authors have pointed out that they have purposely included brief comments on many proposed processes of somewhat questionable value in order to give a complete record on the subject.

Chemical Refining of Petroleum represents a valuable summary of the recent literature dealing with the subject, and in each chapter all the various aspects, including methods of tests where these are essential to a thorough understanding of the subject, are fully considered, and the authors have included a large amount of information not readily available elsewhere.

F. H. GARNER.

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS. Philadelphia, Pa., American Society for Testing Materials. 1933. Pp. 292. $1.25.

This publication brings together in convenient form the many A.S.T.M. standard and tentative methods of test pertaining to petroleum and the 1933 report of the Committee D-2 on Petroleum Products and Lubricants. In all there are 51 test methods given. Many of these have been approved by the American Standards Association and the American Petroleum Institute.

Revisions in several of the standard methods were adopted in 1933 by the Society. These are given in their latest form and cover the following tests: cloud and pour points; viscosity, flash and fire points with open cup, and sulphur in petroleum oils heavier then illuminating oils. Tentative standards included, which were revised this year, cover the tests for penetration of greases and petrolatum and tests for bituminous emulsions.

Several of the methods were adopted as standard this year, having previously been approved as tentative. These new standards involve the following tests: dilution of crankcase oils, distillation of crude petroleum, gravity, precipitation number of lubricating oils, methods of sampling petroleum and its products, loss on heating of oil and asphaltic compounds, and tests for electrical insulating oils.

Other widely used standard tests which are given in the book cover determination of bitumen; burning qualities of kerosine, mineral seal and long-time burning (for railway use) oils; carbon residue; colour of lubricating oils, petrolatum and refined oil; float test for bituminous materials; and specific gravity of asphalts, road oils and tars, asphalt cements, etc.

Other tests relate to analysis of grease; melting point of paraffin wax and petrolatum; detection in gasoline of sulphur and its corrosive compounds; vapour pressure of natural gasoline; water in petroleum products, etc.

The 1933 report of Committee D-2 summarises the changes recommended in the various test methods developed by the committee, and includes an appended technical paper, "A Procedure for Measuring Bleeding of Cup Greases."

SYMPOSIUM ON MOTOR LUBRICANTS. American Society for Testing Materials. 1933. Pp. 121.

The seven technical papers and extensive discussion which make up the published Symposium on Motor Lubricants were presented at a joint meeting in March, 1933, of the A.S.T.M. and the Metropolitan Section of the Society of Automotive Engineers. The symposium was arranged by A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. Subjects covered

include: service requirements, viscosity, carbon deposits, oil consumption, service changes, engine design as affecting oil performance, etc.

The paper on "Carbon Deposits in Gasoline Engines" presents a review of available data on this problem, particular attention being given to the influence of lubricating oils on deposits. Several tests which have been proposed to predict carbon-depositing tendencies of oils are critically discussed.

The relation of the A.S.T.M. pour test to service requirements of oils is outlined in another paper, while a third presentation covers the factors involved in the relationship between viscosity limits of crankcase lubricants and service requirements.

A review of the existing data on changes which crankcase oils undergo during service is presented. There is considerable discussion of this paper included in the printed symposium.

The paper on "Oil Consumption in Motor Car Engines" correlates recent findings on consumption of oil and discusses the more important conclusions resulting therefrom. The effects of engine speed, engine design and oil properties are outlined and conclusions are presented based on motor dyanometer, chassis dynamometer and road tests.

Other topics discussed in the symposium are "Factors in Engine Design which Affect Oil Performance" and "Aircraft Engine Lubrication." This latter paper is confined entirely to the practical application of available oils in aircraft engines and the problems encountered.

Many of the problems discussed in the symposium are controversial ones, and the participation in the discussion by outstanding technologists in the petroleum and automotive industry resulted in a general advancement toward agreement on some of these factors.

Copies are available in heavy paper binding at $1.25 or in cloth binding at $1.50 from the A.S.T.M., 1315, Spruce Street, Philadelphia, Pa.

REPORT ON AERIAL SURVEY OPERATIONS IN AUSTRALIA DURING 1932. W. G. Woolnough. Government Printer, Canberra, by Authority, 1933. Pp. 78, 3 pl., 2 maps.

As the result of a visit to the U.S.A. and Argentina in 1930 to study methods employed in the search for oil, the use of aerial survey was especially stressed and recommended for experiment under Australian conditions.

The first experiments were made in the region of Longreach, Queensland, and the success there obtained led to the work being extended to cover most of the areas considered as being possible for oil development in Australia.

The report deals with the description of the geological results, and it was only the question of expense which made it necessary to exclude technical details of the methods of survey employed. One method which was found of great value was the study of shadow effects in the photographs, and the formula for the calculation of heights from shadows is given.

THE VISCOSITY OF PITCH. By A. B. Manning. Fuel Research Technical Paper No. 39. H.M. Stationery Office, 1933. Pp. iv.+20. 6d. net.

This paper deals with the determination of the viscosity of pitch. An important technical application of pitch is as a binder in the manufacture of briquettes from powdered coal. The investigation described formed part of a programme of work designed to correlate the laboratory tests of pitch with its suitability for briquette-making, but it is probable that the results will also be applicable to other branches of industry.

Briefly, the usual method of making briquettes is to compress, in suitable moulds, hot mixtures of powdered coal and pitch. Since the latter acts as

a binder, the mixing, in the ideal case, should result in the spreading of a thin and uniform layer of pitch over each of the coal particles. It therefore appears, the report explains, that the important factors to be considered in regard to the behaviour of pitch in this process are its surface tension, which measures its wetting power, and its viscosity, which controls its speed of wetting. Of these two factors it was decided to study, in the first place, the viscosity.

The temperature at which briquettes are commonly made is between 90° C. and 100° C. It was, however, decided to investigate the viscosity over the range from 30° C. to 110° C., since the variation in viscosity at temperatures below that at which the briquette is made has probably some bearing on the behaviour of the briquette during and subsequent to cooling. Moreover, the determination of the viscosity over this wide range is of importance in connection with other industrial uses of pitch.

Owing to the large variation in the viscosity of pitch with change of temperature, it was necessary to use three different methods to cover the range from 30° C. to 110° C. After describing the apparatus and method of operation, the report proceeds to discuss the results for five typical coal-tar pitches obtained from different types of carbonising plant.

A sample of bitumen or petroleum pitch was examined by the same methods, and was found to differ fundamentally from coal-tar pitch in its viscous properties.

AN INVESTIGATION OF THE ACCURACY OF THE ROUTINE ANALYTICAL DETERMINATIONS ON COAL AND COKE. By Dr. H. V. A. Briscoe, Dr. J. H. Jones and Dr. C. B. Marson. Fuel Research Survey Paper No. 29. H.M. Stationery Office, 1933. Pp. vi.+38. 9d. net.

This paper deals with an investigation into the accuracy of routine analytical determinations on coal and coke. Most of the results were obtained from investigations carried out jointly at Newcastle-upon-Tyne by the staff of the Department's Coal Survey Laboratory and the staff of the Northern Coke Research Committee.

Accuracy in sampling and in analysing coal and coke is of very great importance, although from the nature of the substances dealt with, it is very difficult of attainment. The question is by no means of academic interest only. Coal is a highly complex substance which, in chemical and physical characteristics, ranges through almost endless variety. This is now recognised in industry, where modern conditions and processes demand a high efficiency only to be achieved, in the case of coal, by careful selection of the coal used. For this reason, the classification of coal, originally an academic investigation, is now of considerable interest to industrialists. This classification, however, is almost wholly based on chemical data, and the question of the reliability of the data becomes important.

It is obvious that every step should be taken to assist the chemist and the fuel technician in their judgment of the degree of accuracy with which they are dealing. The reliance to be placed on the data obtained in the laboratory depends to a larger degree, however, on the accuracy of sampling. When it is realised that the sampling of coal and coke is in itself a very difficult question, it will be seen that the whole problem moves in a vicious circle, for we can only judge the accuracy of sampling by comparing results of chemical analysis, and our judgment of the accuracy of chemical analysis is dependent on the degree of accuracy in sampling.

The present paper forms an important contribution to this subject for, in the work which it describes, the accuracy of the analytical results alone,

freed from the complication of sampling, has been considered on a mathematical basis, with the result that we are placed in a position to judge the accuracy of routine analytical work, gaining, in addition, a clearer view of other aspects of the problem—viz., sampling and the actual methods used in analysis.

In the work on coal, sampling errors were reduced to a minimum. A single block, about 16 lb. weight, was crushed, mixed and divided by coning and quartering into 64 small samples. These were subjected to routine laboratory determination. The results were then tabulated and examined in the light of the mathematical principle known as the Law of Errors. The mathematical formulæ used are given, and the results obtained are tabulated in detail at the end of the report.

In order to investigate the influence of any sampling errors which may have occurred, similar series of 64 repeat determinations were carried out on samples of pure chemical compounds, such as saccharose, phenacetin and medicinal paraffin, in which no sampling errors could arise. The results obtained were compared with those for the coal.

Routine determinations on coke were dealt with in a similar way, one representative sample being divided into 64 laboratory samples on which repeat determinations were carried out. The results were tabulated and examined mathematically as before.

The report discusses in some detail the degree of accuracy to be expected in laboratory work on coal and coke, not only with one worker in one laboratory but, supported by figures obtained in the course of routine work at the Fuel Research Station and elsewhere, as between different laboratories.